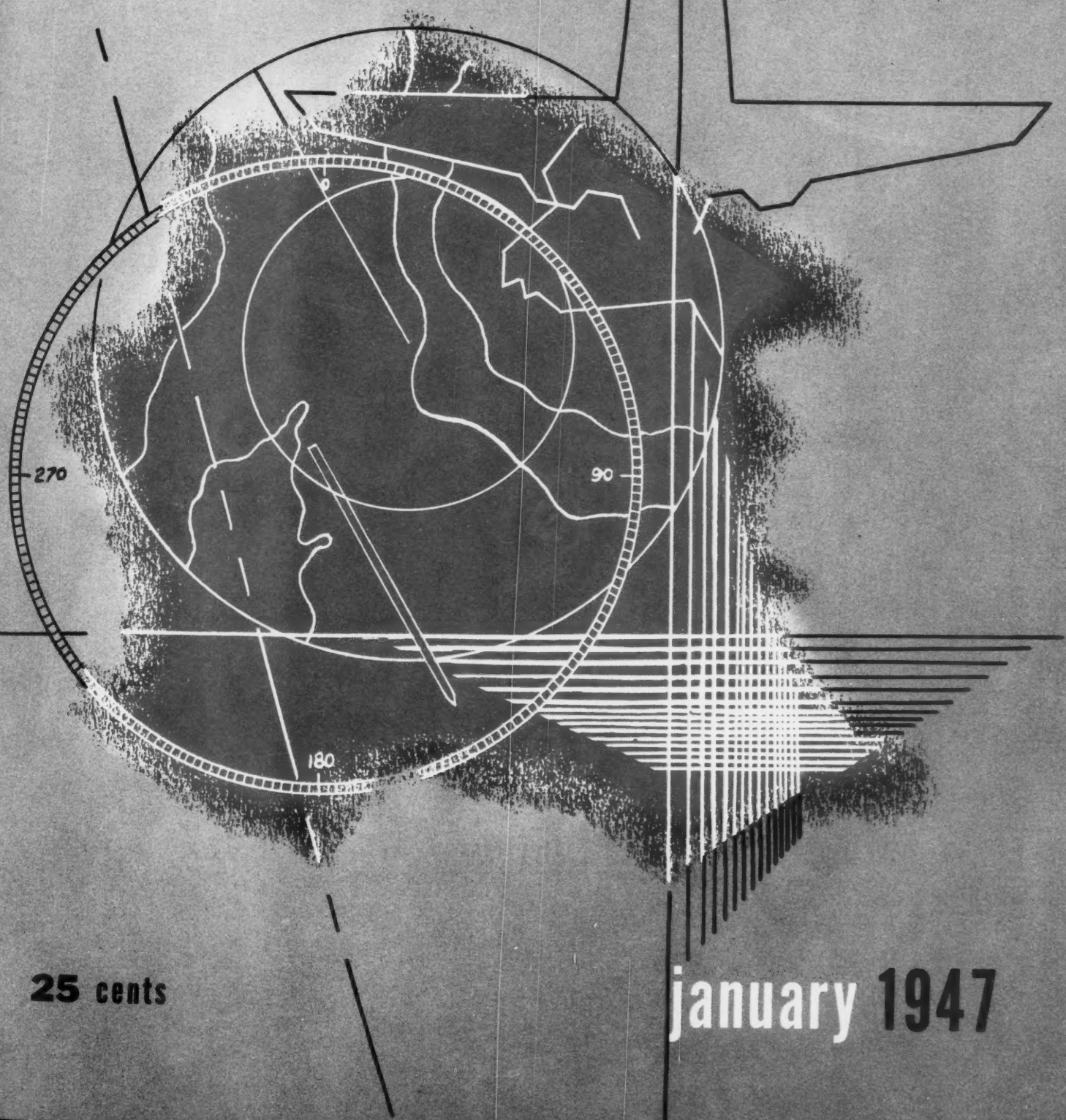
the tech
ENGINEERING NEWS



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HANNIBAL'S FROZEN ASSET

The Romans smugly thought the icy barrier of the Alps impassable. But Hannibal turned the paralyzing cold to his advantage. He had water poured into the crevices of road-blocking boulders. The expansion of the freezing water "made little ones out of big ones"—and another road led to Rome.

Low temperature, which worked to Hannibal's advantage, is a distinct disadvantage to operating machinery. Under low temperature conditions, some steels that may perform perfectly at ordinary temperatures, develop unsuspected weakness. There is always danger of a parts failure under such conditions.

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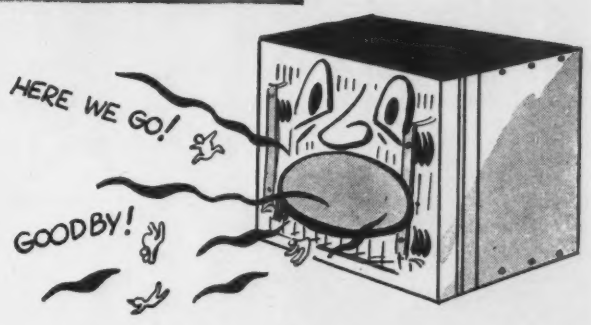
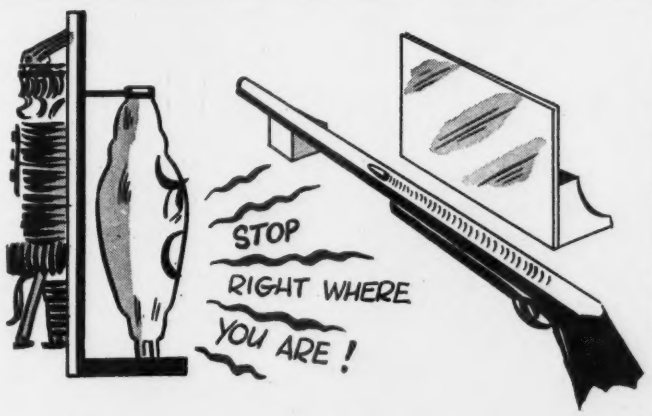
What's your S.Q.*?

1.—THE "RADIUM HOUND," for tracking down lost radium, is so ultra-sensitive that it can detect the presence of (a) 4 quadrillionths, (b) 25 billionths, (c) 17 thousandths of an ounce of this precious metal?



2.—THE PRECIPITRON is a device for removing 95% of all solid matter from air. It does this by —(a) capillary action, (b) electrostatic attraction, (c) osmosis?



3.—A REVOLUTIONARY X-RAY can now "freeze" the image of a bullet while traveling through a high-powered rifle. This X-ray tube takes a picture in —(a) 3/10,000th, (b) 15/100,000th, (c) 1/1,000,000th of a second?

4.—IF YOU HAD a piece of string one astronomical unit long, would it stretch —(a) 115,562 miles, (b) 92,897,416 miles, (c) one light year?

ANSWERS

1.— (a) This electronic device . . . developed by Westinghouse scientists . . . is also useful for determining the safe therapeutic dosage of radium, radon, and X-radiation.

2.— (b) The Westinghouse Precipitron removes dust, pollen, smoke and other particles as small as 1/250,000th of an inch, by ionizing the particles and attracting them to electrically charged plates.

3.— (c) Developed by Westinghouse research engineers, this millionth-of-a-second X-ray also aids U.S. Army ballistic experts in studying the action of armor-piercing bullets penetrating steel armor plate.

4.— (b) This is an easy one. The picture almost gave it away; the mean distance from the earth to the sun.

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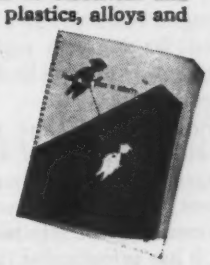

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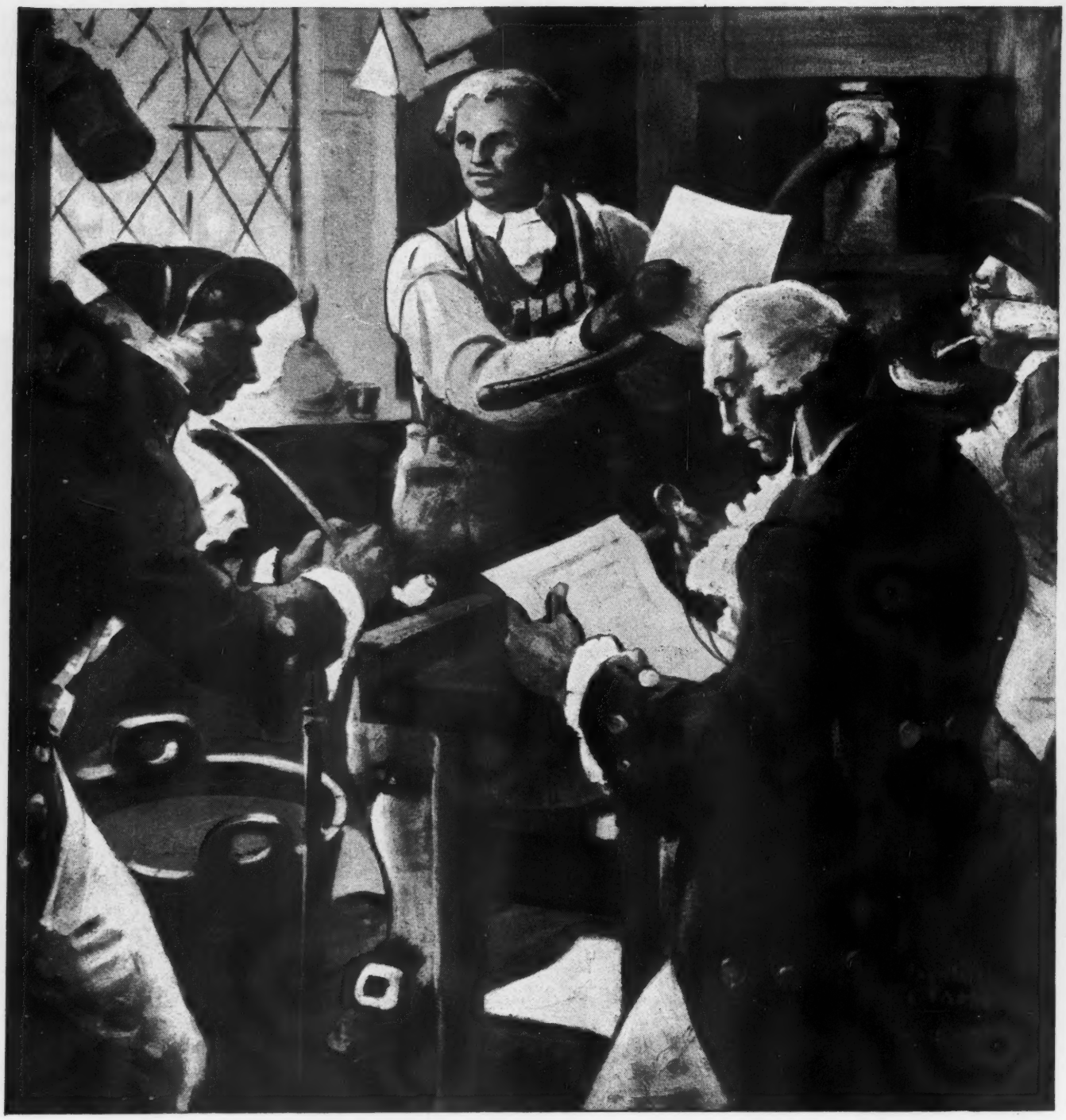

He borrowed to create a business

Benjamin Franklin believed in hard work. He started his printing business on a shoestring, with borrowed money. His credit and reputation were good because he was thrifty and industrious. He delivered his printing to customers in a wheelbarrow; worked far into the night frequently. From literally nothing he developed a respected business.

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. . .

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Briefing the News . . .

Perambulating Ocean . . .

ONE of the latest additions to the United States Navy's testing facilities has been a circulating water channel, through which 2500 tons of water are circulated at speeds up to twelve miles per hour. Models of ships can be placed in the current of water, and the flow of water around the models simulates the performance of full-scale ships in plowing through the water of the sea.

The channel has glass walls, through which the currents and eddies around the models can be observed and photographs can be taken. The water is pumped by two 1000 horsepower Westinghouse motors attached to variable-pitch propeller blades, and the velocity of flow of the water can be changed by varying the pitch of the impeller blades.

Non-Metallic Magnets . . .

Small non-metallic permanent magnets, consisting of highly compressed oxides of iron and cobalt, have been developed to serve in electric meters in aircraft. Like the magnetic oxide of iron, Fe_3O_4, the mixed oxides of iron and cobalt are highly magnetic. Unlike metallic magnets, however, the oxide magnet is not a conductor of electricity, and therefore the eddy currents that usually form in the magnet of an electric meter are eliminated. As a result, the new meters are among the most accurate as well as the lightest ever devised.

Radar on the Great Lakes . . .

News has come from Western Electric Company that Radar is being used to safeguard the shipping fleets on the Great Lakes, especially because of the narrow channels between the lakes through which a very large amount of shipping passes. Six companies have already installed the new Radar apparatus, which is of the plan position indicator type which shows a view of the lake and shoreline around a vessel on the fluorescent screen of a cathode ray tube, regardless of the nature of the weather.

Tests are being carried out by the Lakes Carriers Association with the cooperation of the Coast Guard, and it is expected that they will recommend the use of Radar on all ships.

Return of the Platinum Metals . . .

Due to their extensive wartime use, platinum and the metals closely related to it chemically have been almost unattainable. Now they are beginning to flow back to market, and their all-time high prices have started back to normal.

Some of the very rare metals related to platinum, such as osmium, rhodium, and ruthenium, have been put to a considerable number of peacetime uses. Ruthenium in particular is in demand to make hard platinum and palladium alloys for jewelry, the points of fountain pens, etc. Rhodium has also returned to the civilian market in rhodium alloy jewelry and rhodium plated articles.

Life on Mars . . .

The problem of the existence of life on Mars may soon be solved by astronomers with the aid of a new photosensitive cell developed by Dr. G. P. Kuiper of the University of Chicago and Drs. R. J. Cashman and W. Wilson of Northwestern University. The invention is a tiny photoconductive cell made of lead sulfite, which is especially sensitive to infra-red or heat rays.

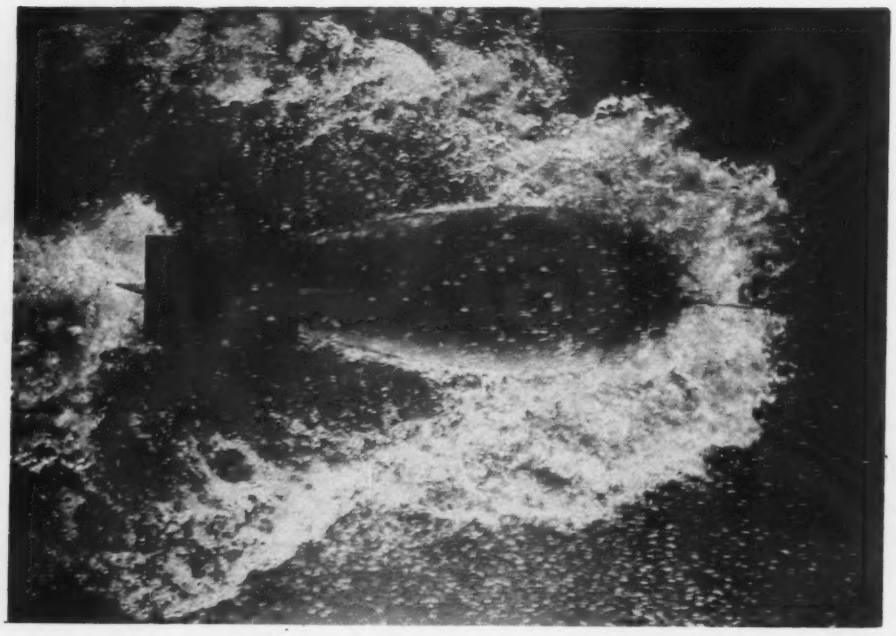
With the new apparatus, which is reported to be a thousand times as sensitive as any previous instrument, many interesting things have been discovered about the planets Saturn and Venus, and about the little-understood giant red stars.

Its possible application to the discovery of whether life exists on Mars is due to the unusual way in which chlorophyll, the green coloring matter of plants, reflects infra-red light. Chlorophyll is an excellent reflector of heat rays, so that infra-red photographs of plants show them as having white leaves. The infra-red absorption spectrum that chlorophyll does possess, however, is distinctive.

Scientists have long observed certain green markings along a series of channels running between the polar caps of Mars. It has been speculated that these channels carry water from ice-bound polar caps, and that the green markings are vegetation growing along them. Since the chlorophyll of plants has such an unusual infra-red spectrum, the matter may soon be decided with the new infra-red electric eye.

Underwater view of a buoy anchored in a moving stream of water in the Navy testing tank

Westinghouse



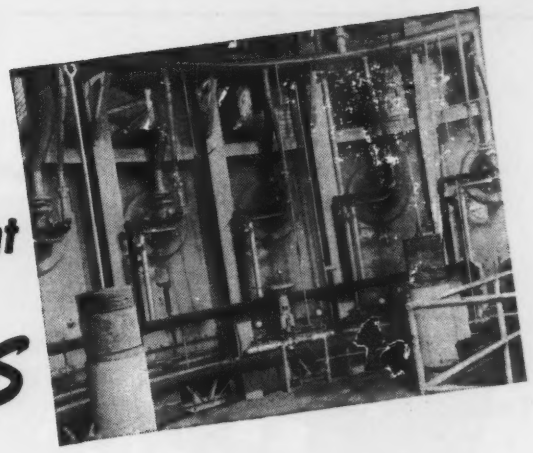
World's largest rotary furnace

AT

The Timken Roller Bearing Company plant

CANTON, OHIO

proves adaptability of GAS



An outstanding example of adaptability of Gas and Gas equipment in successfully solving any industrial heating problem is seen in the world's largest rotary furnace used to heat alloy steel billets for piercing into seamless steel tubing at the Canton, Ohio plant of The Timken Roller Bearing Company.

Here, equipment engineers were called upon to build a furnace for heating round billets up to 10" in diameter and 12' in length, which would do the job more economically than existing equipment.

The result is this Gas giant with 2100 sq. ft. of hearth area and a capacity of 80,000 lb. per hour, when heating billets up to 2250°F. Speed of the hearth ranges from 2 to 8 hours per revolution. Temperature control is fully automatic and a single operator can determine the temperature and location of each billet at any instant during the heating period. Since the start of operations, this Gas furnace has saved an average of 2% in scale loss alone. Maintenance costs are at a minimum and six men per turn were released for other plant duties.

Manufacturers of Gas-fired industrial equipment, cooperating with Research Engineers of American Gas Association, have applied Gas, successfully, to thousands of manufacturing operations. The characteristics of Gas make it the ideal fuel for industrial heating and heat-treating.

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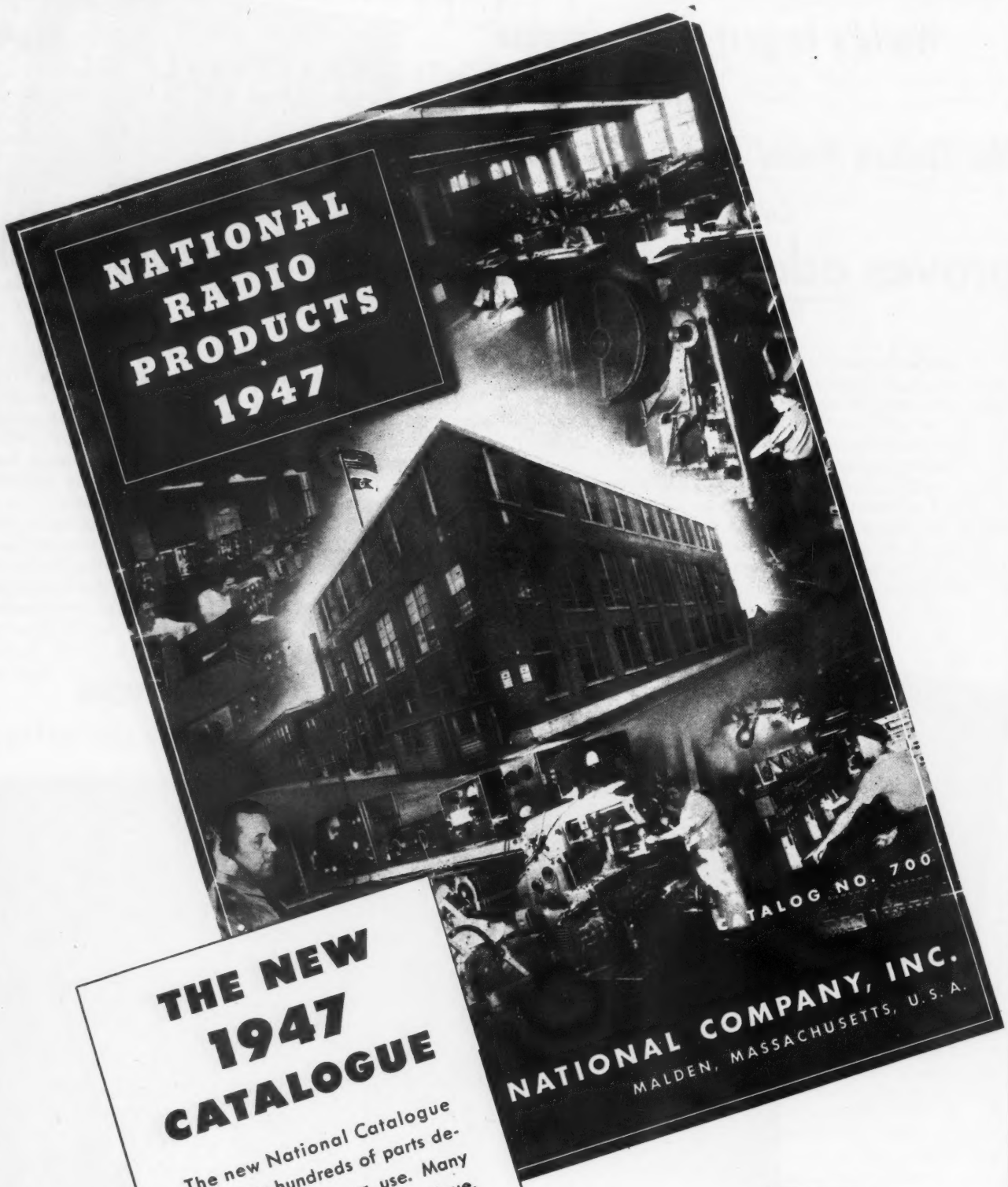

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The TECH ENGINEERING NEWS

PROFESSIONAL JOURNAL OF THE UNDERGRADUATES

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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JANUARY, 1947

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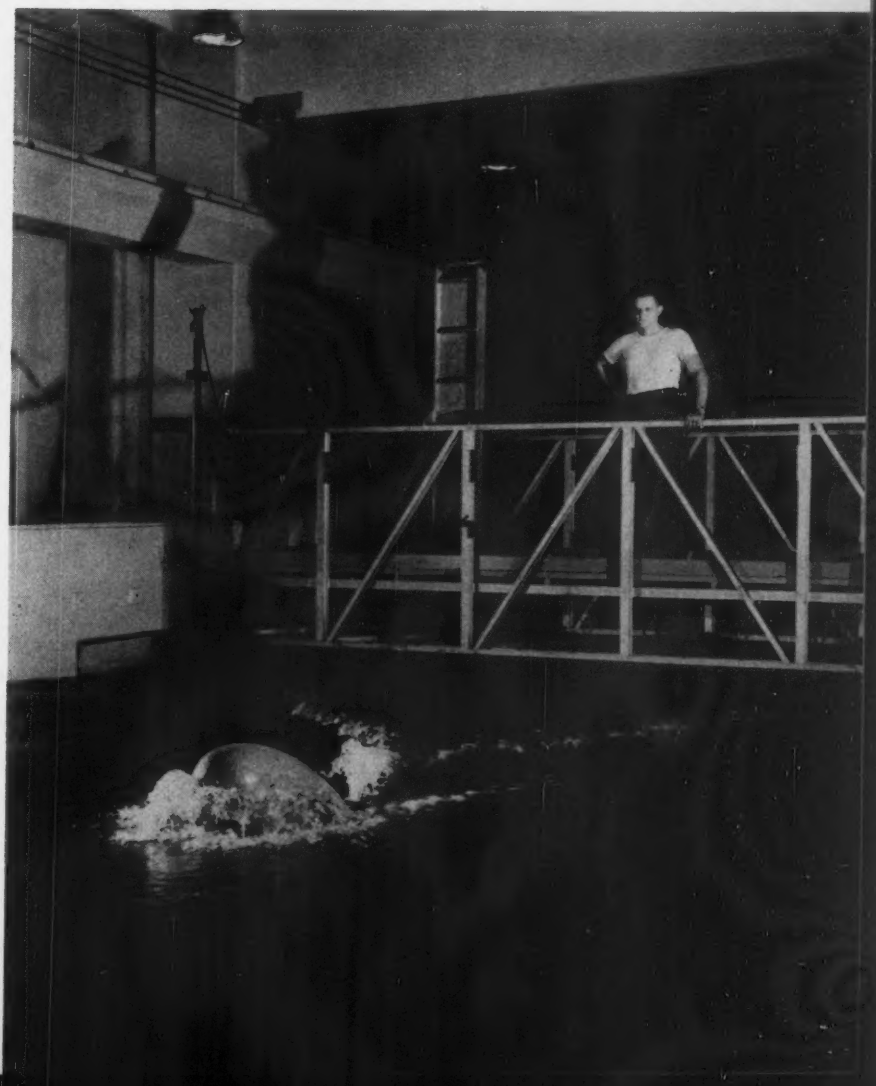
Westinghouse



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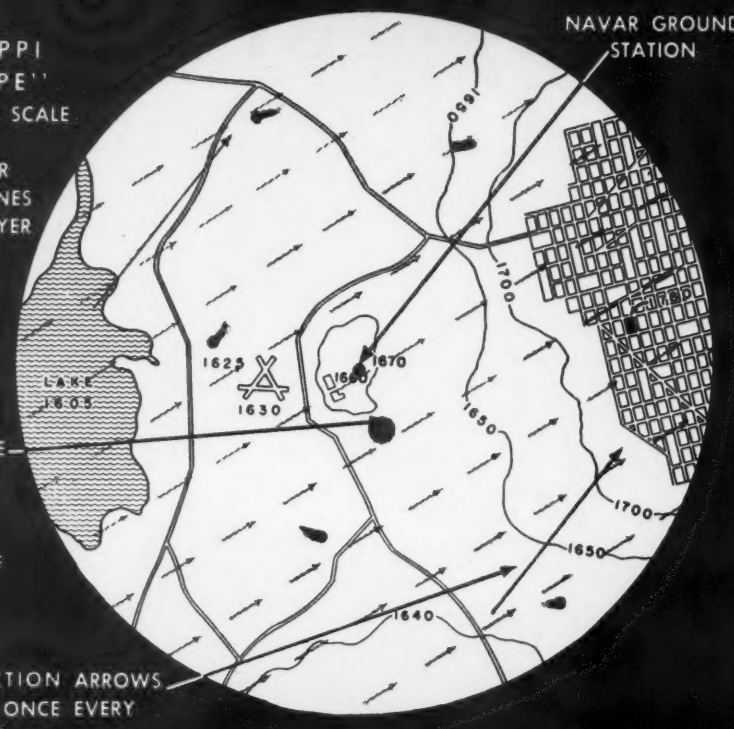
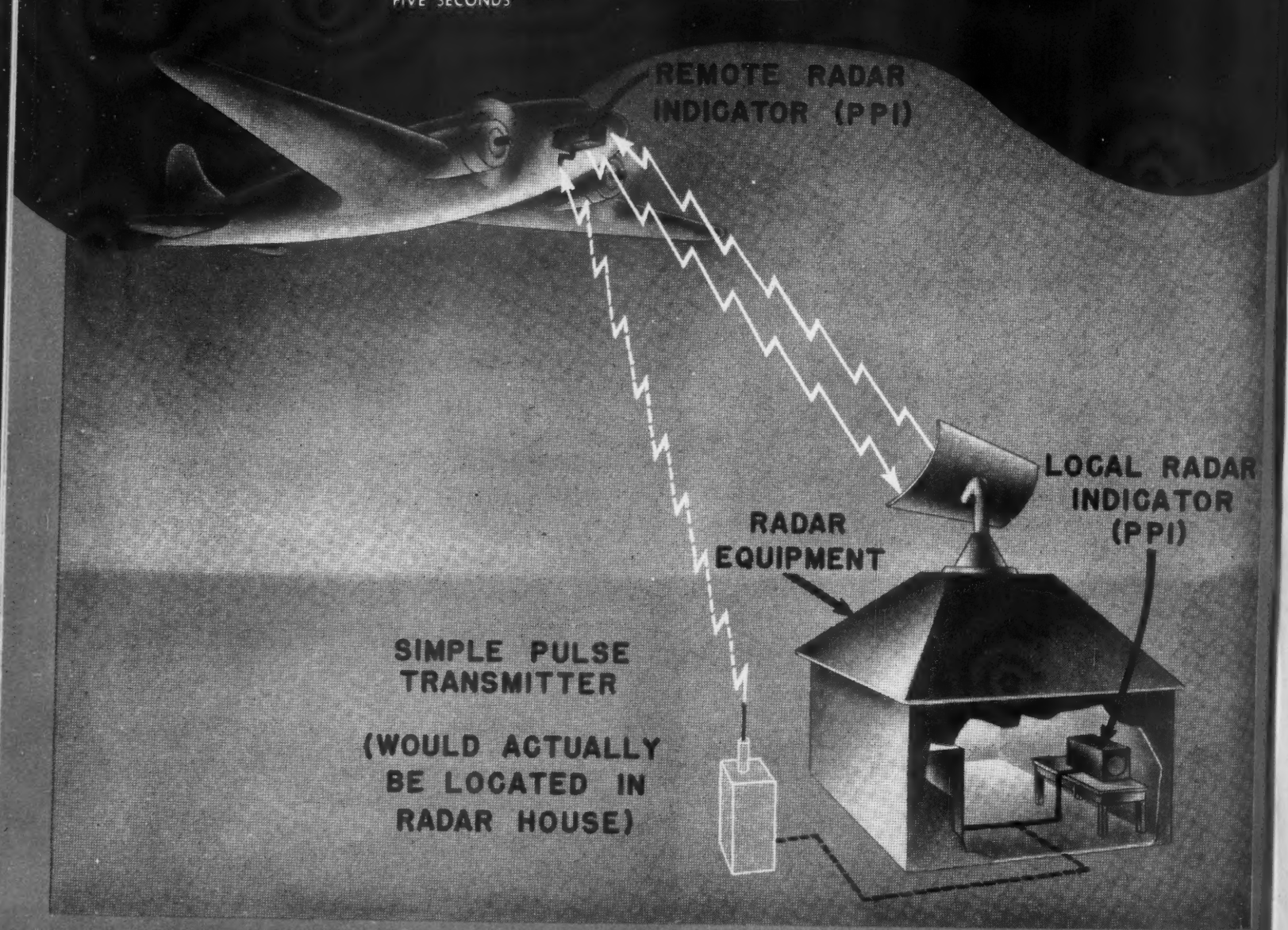
POSITION OF OBSERVER'S PLANE

GREEN ARROWS SHOW HEADING OF OWN AIRPLANE

WIND DIRECTION ARROWS SHOW ONLY ONCE EVERY FIVE SECONDS




REMOTE RADAR INDICATOR (PPI)
LOCAL RADAR INDICATOR (PPI)
RADAR EQUIPMENT
SIMPLE PULSE TRANSMITTER
(WOULD ACTUALLY BE LOCATED IN RADAR HOUSE)

Navar

By EDWARD T. MILLER, '49

All pictures and diagrams courtesy of the Federal Telecommunications Laboratories of the International Telephone and Telegraph Corporation

WHEN we look up at the sky, there seems almost to be an infinity of space in which we can fly. In a sense that is true, for in relation to the total volume of flyable atmosphere, the amount of space occupied by all the airplanes the world will use in the foreseeable future is negligibly small. Yet nearly every day because of overcrowded airways flights are cancelled at one point or another in the United States. This is annoying to the travelers who are subsequently put at considerable inconvenience. They suffer a loss of the very thing they are trying to save by flying — their time. Such flight cancellations also bother the airlines, for they not only lose the immediate business, but they lose customers who value reliability more highly than the hours saved by flying.

This is aggravated all the more by the knowledge that weather in all but its very severest form presents no insurmountable obstacle to keeping aloft the modern airplane with its latest improvements. Planes can fly perfectly well through the average weather that causes flight cancellations, but being able to fly and being able to avoid other planes while flying are two different problems. In general there may be plenty of space in which to fly, but airliners fly to particular places, and there are usually many more flights than one scheduled for the same city and along similar paths.

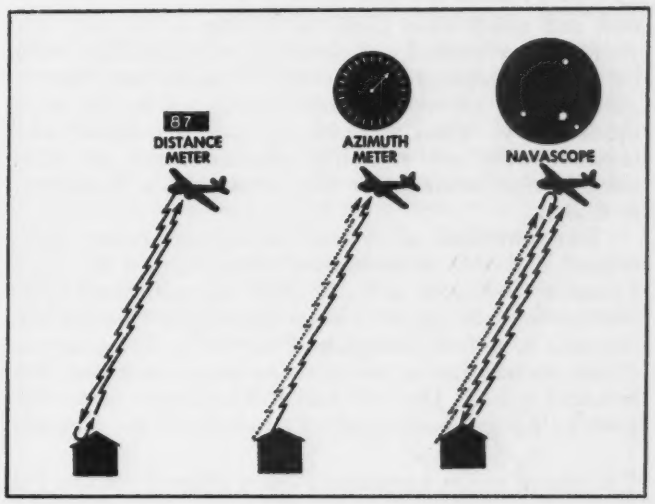
Everything works out all right when weather permits a pilot to see where he is flying. When, however, there occurs even a slight fog, not hindering the plane's flying ability at all, but just the same forcing the pilot to fly blind, the pilot must tune into existing navigational systems to keep from colliding with other airplanes. The basic principle of the present type of navigational aids is the radio beam. It provides for a narrow lane between two stations (usually airports) along which planes can fly blind and be guided by ground personnel who have over-all information for the lane.

Usually each lane has to serve for flights in both directions and the only way to segregate them is by altitude. Then there is the difficulty of intersecting lanes.

It all adds up to a complex traffic problem which has to be guided by men and not machines on the ground. The information gathered for these traffic controllers is gathered from numerous sources and presented before them in a static picture which they have to make kinematic in their minds. They must then verbally communicate with the pilots when conditions of danger exist.

Under this system the available space for airplanes is quickly filled. Flying along those narrow lanes usually limits the speed of every plane to that of the slowest, since there are no safe ways of passing. Then when the planes on a particular beam flying towards a certain airport get there, the problem of getting them on the ground springs up. If, as quite often happens during bad weather, more planes are arriving than can land, the planes are stacked. This means that each plane is assigned an altitude by the airport where it circles around until permitted to land. This stacking is costly to the airlines, and it cannot be done indefinitely. Eventually the air may become so crowded that planes are prevented from approaching the airport and are ordered to circle around where they are. Consequently, it is possible when bad weather exists over New York City to have flights from Washington to there cancelled, even though there is clear weather along most of the way.

The present radio beam system is safe enough for the traffic it handles, but it is so very inadequate compared to the amount of business the airlines could do that great effort has been made to bring forth a new system out of the many discoveries and developments

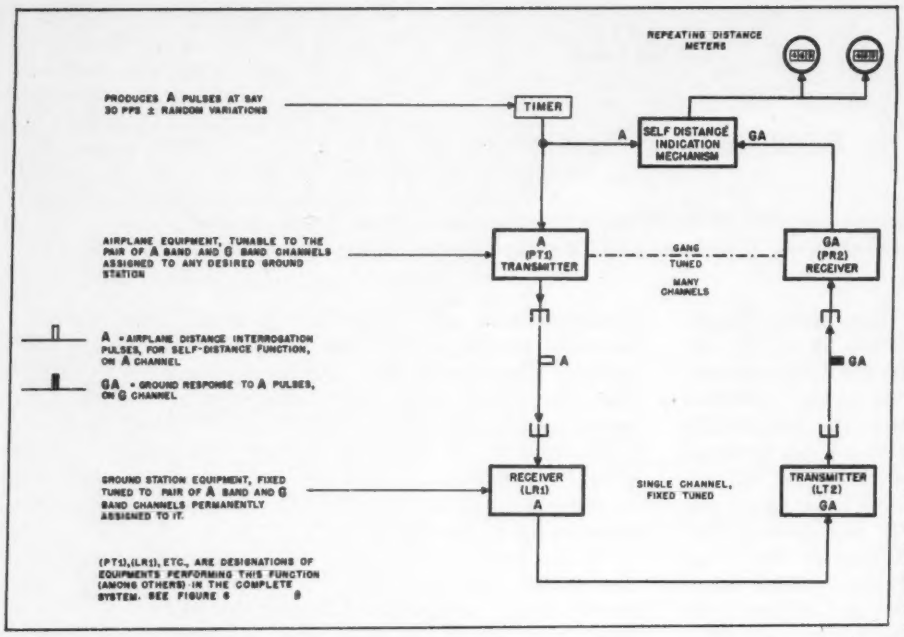


Different functions of the Navar system

that occurred during the War. International Telephone and Telegraph, through its Federal Telecommunications Laboratories, has been working on a system called Navar. The other major system being developed is R. C. A.'s Teleran.

Both systems are built around a ground surveillance radar station which does the greater part of the task. Both ground units present the location, etc., of the planes covered on a PPI (plan position indicator) scope. The major difference between the basic philosophies of each is that Navar transmits the pictorially represented information gathered by the ground unit to the plane by means of a radar technique while Teleran does it by television. In this article we shall consider in some detail the Navar system.

The major services provided to the airplane under the Navar system may be divided into five units. Each of these functions can be achieved more or less independently of the others by different sets of equipment, and yet they can be combined, making use of equipment mutually, and thus molded into one system requiring a minimum number of transmitters and receivers. It was Federal's policy to get a general idea of navigational problems which confront the airlines


REPEATING DISTANCE METERS
PRODUCES A PULSES AT SAY 30 PPS ± RANDOM VARIATIONS
TIMER
A
SELF DISTANCE INDICATION MECHANISM
GA
AIRPLANE EQUIPMENT, TUNABLE TO THE PAIR OF A BAND AND G BAND CHANNELS ASSIGNED TO ANY DESIRED GROUND STATION
A (PT1) TRANSMITTER
GANG TUNED
MANY CHANNELS
GA (PR2) RECEIVER
A • AIRPLANE DISTANCE INTERROGATION PULSES, FOR SELF-DISTANCE FUNCTION, ON A CHANNEL
GA • GROUND RESPONSE TO A PULSES, ON G CHANNEL
A
GA
GROUND STATION EQUIPMENT, FIXED TUNED TO PAIR OF A BAND AND G BAND CHANNELS PERMANENTLY ASSIGNED TO IT.
RECEIVER (LR1) A
SINGLE CHANNEL, FIXED TUNED
TRANSMITTER (LT2) GA
(PT1),(LR1), ETC., ARE DESIGNATIONS OF EQUIPMENTS PERFORMING THIS FUNCTION (AMONG OTHERS) IN THE COMPLETE SYSTEM. SEE FIGURE 6 9

Airplane Self-Distance function

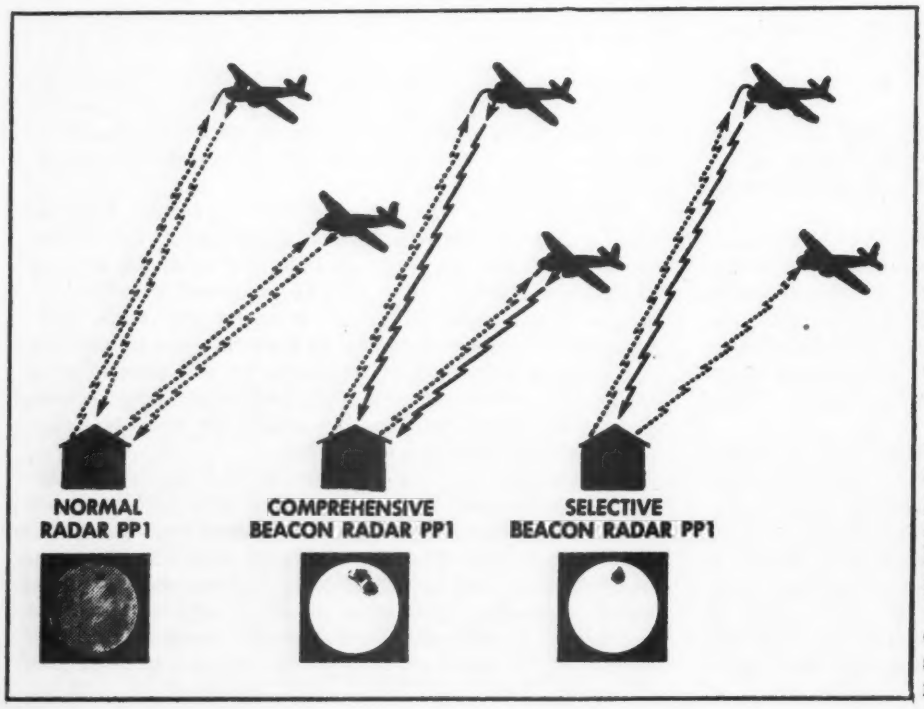
now and which seem likely to develop in the next ten years. They wanted a system whereby remedies could be adopted separately in order of importance and a system that allowed present techniques to be used immediately. Thus it would be able to expand and improve with new scientific developments and also meet further problems as they arose with a maximum flexibility.

Two functions of Navar, based on known techniques, and able of immediate adoption, are the Self-Distance Indicator and the Self-Azimuth Indicator. The former tells the pilot via a suitable instrument the distance he is from the ground station he has selected. (Each station has a radius of coverage of about one hundred miles.) The Self-Azimuth Indicator shows the pilot by a pointer mounted on a radial dial the azimuth of his plane relative to the ground station to which he is tuned. That is the angle between his plane and the north as viewed from the particular ground station.

Before we consider how either of these services functions, we ought to note the RF (radio frequency) channels used by the whole Navar system. First there is the common R (radar) channel used by all ground stations to locate the planes within their radii of coverage. Then there is the G (ground transmission) channel. Each ground station has assigned to it an individual G channel used for sending pulse messages to the planes tuned to it. Finally there is the A (air transmission) channel. Each airplane sets its transmitter to a certain A channel corresponding to the ground station it has its receivers tuned to. The A channel is used by the plane to send pulse messages to the ground station. It must be understood that these messages are not verbal but are coded systems of pulses which will signify something to the receiving set. Such messages can range from a set of pulses standing for a certain altitude to a signal indicating the angle or distance of an object.

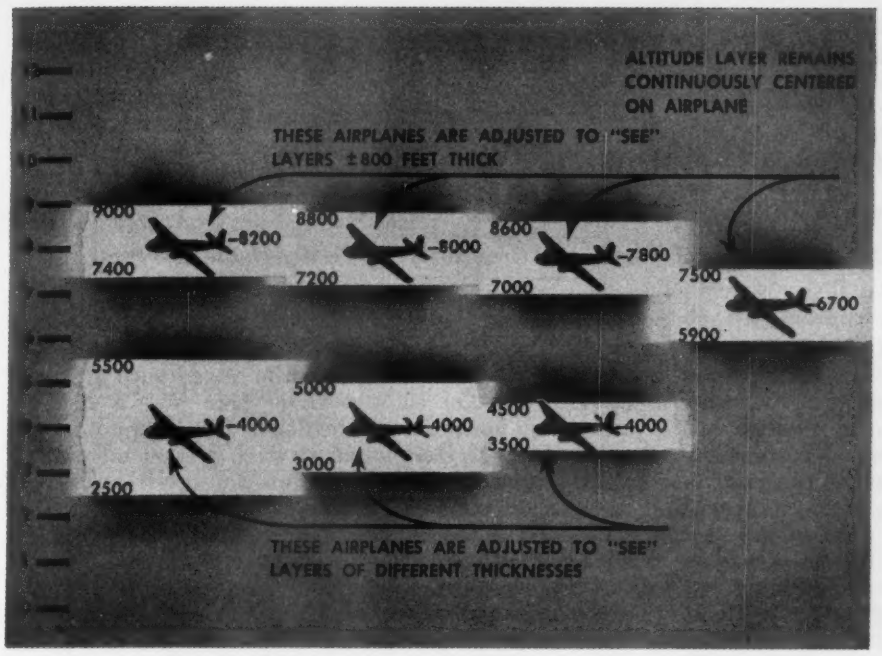
For the Self-Distance function the airplane's transmitter sends out over the A channel it is tuned to pulses with a slight random variation in the number per second. These pulses are picked up by the receiver at the ground station to which the particular A channel corresponds and are retransmitted omnidirectionally by the ground station in its G channel. The plane's receiver, which is tuned to this G band, picks up the answer, and by gauging the time for the answer to an individual pulse to come back, an electro-mechanical device can be made to read the distance from the plane to the station.

The three main variations on a Plan Position Indicator system



Because of the random variation of the pulses originally sent out, the plane can pick out the answer meant for it irrespective, within reason, of the number of other planes using the same station for a self-distance measurement. The random variations used by the other planes will not correspond to the given plane's variation for any appreciable length of time, and therefore an arrangement is made for registering only the G pulses with the given plane's random variation. This function, alone, requires a receiver and a transmitter in the plane and also one of each at the ground station.

In the Self-Azimuth operation the ground station sends out over the R channel an accurately directed pulse at a given number of times per second, for instance 600 pps. This beam of pulses rotates about at a fixed number of times per second. While all stations use the same R channel, they do not use exactly the same number of pps or the same rotational rate.



Variation of layer displayed

The ground station also sends out omnidirectionally over another transmitter set for its G band pulses, G_s, exactly synchronous with its directional radar pulses. These pulses in the G channel are received by the planes with one of their receivers tuned to the given station. Each time a G_s pulse is received, it opens a gate allowing directional radar pulses to register if there happens to be a beam directed at the plane. Thus only directional radar pulses received regularly are from the chosen ground station. Coupled with this, the ground station also sends out omnidirectionally a special pulse, G_n, over its G channel every time its radar beam is directed north. If the rotational rate of the beam is known, an electro-mechanical system can use the time difference between the arrival of the G_n pulse and the directional radar pulse to measure the plane's azimuth relative to the station. The Self-Azimuth operation by itself uses two transmitters at the ground station and two receivers in the plane.

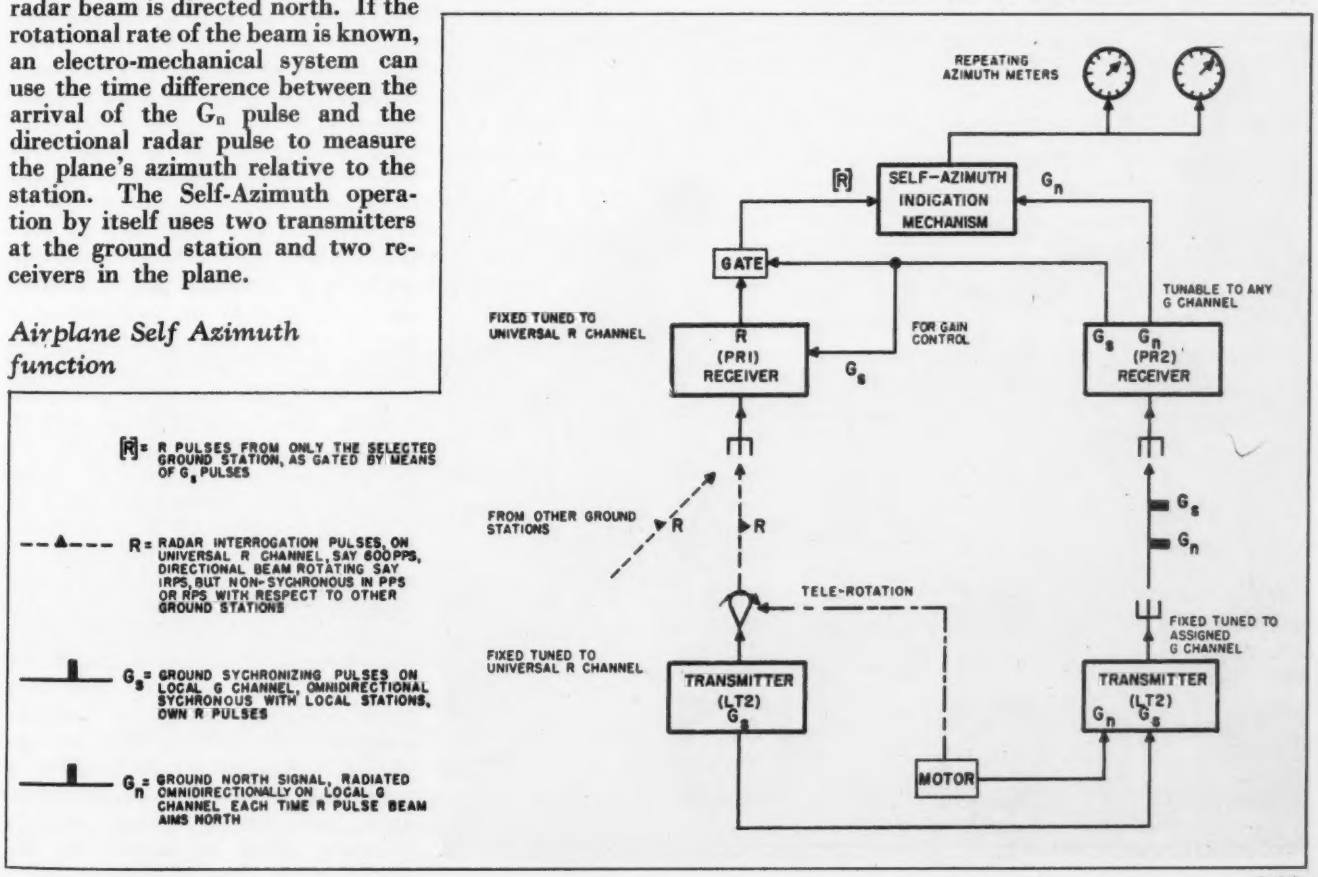
Airplane Self Azimuth function

With the Self-Distance and Self-Azimuth feature both installed in a plane, it is possible for the pilot to fly any radial or circular course with respect to the ground station by his instruments alone. With these two indicators assisting an autopilot either of those courses can be flown automatically, and if an extra computing circuit is added any straight course known as an offset course can be flown.

Next we can consider the function of Navar known as Navaspector — a ground surveillance radar system which combines normal reflection response and beacon response radar. Three sets of information are gathered and displayed on scopes at the ground station. First there is a transmitter on the ground which sends out directional radar pulses, R, in the common R channel. The station is equipped with a directional receiver to pick up reflected pulses, RR. By automatically calculating the distance of the object, usually a plane, causing the reflection and combining this with the direction of the object from the station, the ground station has the necessary information for showing the object as a blip (dot of light) on a PPI scope whose center represents the location of the station. However, this normal radar (NR) scope depends on reflected pulses, which are very weak, and thus there is bound to be interference at times. In addition to lack of clearness on the NR scope, other things besides airplanes may get represented.

With the planes carrying beacon responder sets,

(*Continued on page 160*)


[R] = R PULSES FROM ONLY THE SELECTED GROUND STATION, AS GATED BY MEANS OF G_s PULSES
R = RADAR INTERROGATION PULSES, ON UNIVERSAL R CHANNEL, SAY 600 PPS, DIRECTIONAL BEAM ROTATING SAY 1 RPS, BUT NON-SYCHRONOUS IN PPS OR RPS WITH RESPECT TO OTHER GROUND STATIONS
G_s = GROUND SYCHRONIZING PULSES ON LOCAL G CHANNEL, OMNIDIRECTIONAL SYCHRONOUS WITH LOCAL STATIONS, OWN R PULSES
G_n = GROUND NORTH SIGNAL, RADIATED OMNIDIRECTIONALLY ON LOCAL G CHANNEL EACH TIME R PULSE BEAM AIMS NORTH
REPEATING AZIMUTH METERS
[R]
SELF-AZIMUTH INDICATION MECHANISM
G_n
GATE
TUNABLE TO ANY G CHANNEL
FIXED TUNED TO UNIVERSAL R CHANNEL
R (PR1) RECEIVER
FOR GAIN CONTROL
G_s
G_s G_n (PR2) RECEIVER
FROM OTHER GROUND STATIONS
R
R
G_s
G_n
TELE-ROTATION
FIXED TUNED TO ASSIGNED G CHANNEL
FIXED TUNED TO UNIVERSAL R CHANNEL
TRANSMITTER (LT2) G_s
TRANSMITTER (LT2) G_n G_s
MOTOR

Cosmic Ray Phenomena

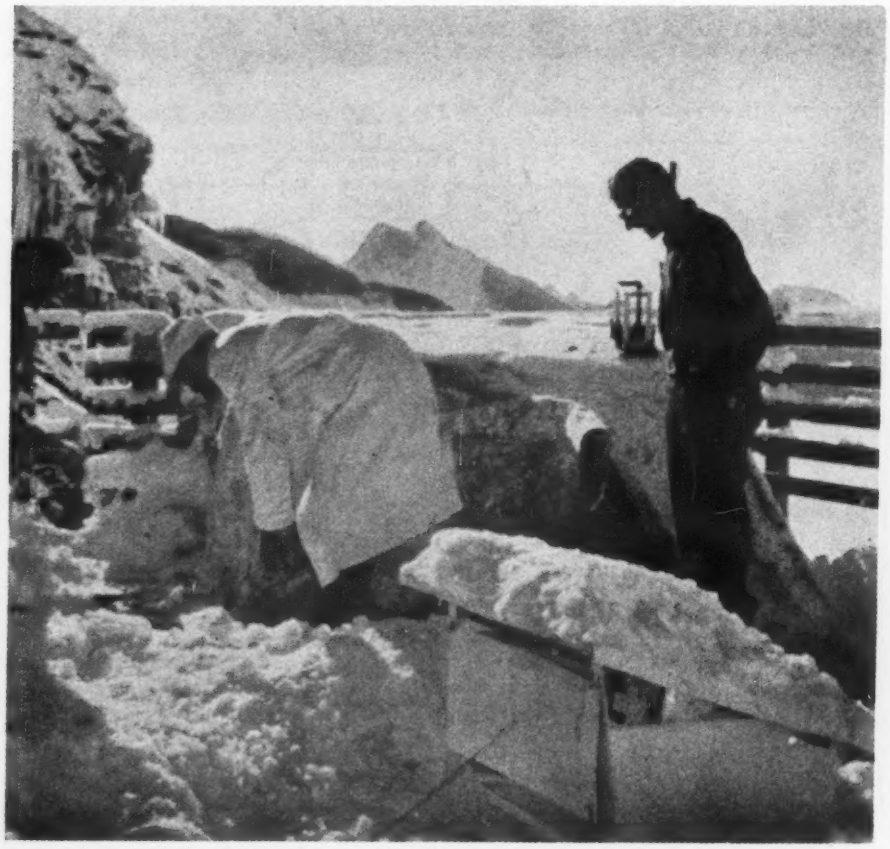
By HARRISON WHITE, '50

Pictures and diagrams courtesy of "What Are Cosmic Rays?" by Pierre Auger, University of Chicago Press

EVERY minute of our lives over a thousand cosmic rays traverse our bodies. Yet, until early in this century, we had not the vaguest notion that such rays existed. Residual ionization was the key which unlocked the hitherto unsuspected door to cosmic ray phenomena. In the course of experiments designed to lead to a more perfect understanding of the nature of ionization, a number of investigators were, at the turn of the century, trying to eliminate all ionization from a given sample of gas. No matter how well the gas was shielded, however, it remained ionized to a slight extent. After many unsuccessful attempts at eliminating this ionization by improving experimental methods, most of the workers dismissed it as "residual" and unimportant. Certain investigators — notably Wilson, Gockel and Hess — were not, however, satisfied. They found that normal air at sea level was ionized to the extent of twenty ion pairs per cc. per second. By placing thick shields of metal around their ionization counters, these investigators were not able to cut the number of ionizations below two per cc. per second. Then they decided to find out how much farther the count would decrease when the counters were moved into the atmosphere away from the earth, whose radioactive impurities were, supposedly, causing the residual ionization. To the amazement of the investigators, the residual ionization increased with altitude! In 1909 Gockel showed that there was a distinct increase in ionization at the height of two and one-half miles. In 1910 Hess found an even greater increase in residual ionization at higher altitudes. Hess was the first one to propose that this residual ionization was caused by rays coming from outside the atmosphere (Höhenstrahlung). For his work, Hess received the Nobel prize. In 1913 W. Kolhorster attained a height of six miles, at which altitude the residual ionization was increased by a factor of thirty. There was no longer any doubt that a significant phenomenon had been discovered.

Before we go on to a closer study of cosmic ray phenomena and theory, it would be well to understand the devices used in cosmic ray research. The electroscope, the Geiger-Muller counter, photographic plates, and the Wilson cloud chamber — these are the tools of the cosmic ray investigator. The electroscope consists of a volume of gas imprisoned between two electrodes at a potential difference. If a charged particle penetrates the gas, ion pairs will be produced; these charged ions will carry current between the two electrodes. Hence we can measure the intensity of an ionizing beam by the amount of current produced in the electroscope. Often, however, it is desirable to be able to register the passage of a single particle. The Geiger-Muller counter is the device best suited to make such detections. In its usual form the counter consists principally of a thin wire stretched axially through a copper cylinder between the ends of an evacuated glass tube which contains both the cylinder and the wire. The cylinder and the wire are connected to the opposite terminals of a powerful battery, and usually there is a resistance of one or two megohms in series with the circuit. The tube is filled with a mixture of gases such as argon and oxygen under a pressure of about 76 mm of Hg. As soon as a particle enters the counter, it produces ions ranging in number from one to sixty pairs per centimeter of path, depending on the energy of the particle. Under the influence of the large field which exists between the electrodes, the primary ions are given sufficient energy to produce ionization themselves; thus an appreciable current is produced in a very short time. The large resistance provides a great enough damping effect to choke off the

Measuring cosmic rays in the Swiss Alps



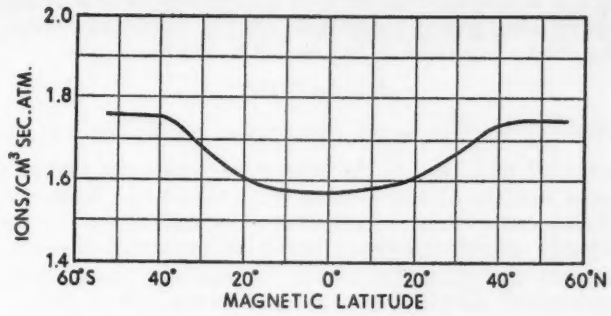


Figure 1: Clay's latitude curve, showing the equatorial depression in cosmic ray intensity, and the two polar plateaus. (After Clay.)

current after a short time, clearing the counter quickly enough so that the time required in detecting a single particle is less than a few thousandths of a second. If two or more counters are set up in a straight line, it is possible to arrange their electronic circuits so that no counts are recorded unless all the counters are discharged at the same time. The result is that the passage of a particle is not recorded unless it is coming from such a direction that it can pass through all the counters. Such a setup is termed a coincidence counter, and is used in determining the place of origin of ionizing rays. To most people, the cloud chamber is the most satisfying of all the instruments used for detecting ionizing rays, because you can actually see what happens. The principle of the cloud chamber is simple; ions formed in a gas supersaturated with water vapor are cores around which droplets of water tend to form. Therefore, when a chamber filled with gas saturated with water vapor is suddenly expanded and hence cooled, droplets of water will be able to form on the ions which will be present if an ionizing particle has just passed through the chamber. A camera is set up so that it will automatically photograph the chamber every time an expansion takes place. The cloud chamber can be used much more efficiently when it is hooked up with a Geiger-Muller coincidence counter circuit in such a way that expansions take place only when the counters above and below the chamber have both been discharged.

When ionizing rays strike photographic plates, they leave behind a trail of black silver particles which clearly delineate the path of ray; consequently, photographic plates are often used in the detection of ionizing particles, since the plates provide a cheaper, though less accurate, means of detection than the cloud chamber. In summary we might say that there are four principal devices for the detection of ionizing rays: ionization chambers which measure the intensity of the ionizing beam; Geiger-Muller counters which record the passage of a single ionizing particle; and lastly, Wilson cloud chambers and photographic plates, both of which show the path of the ionizing particles.

Let us now resume the discussion of cosmic ray phenomena. The first World War interrupted the work of the cosmic ray investigators, but immediately

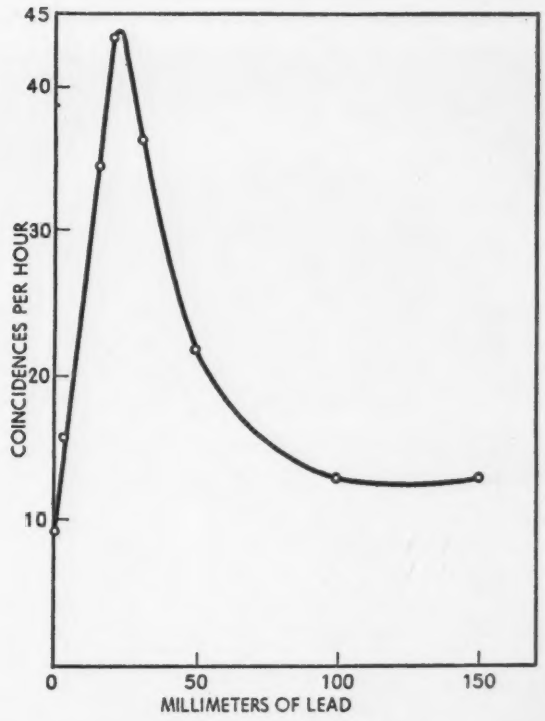
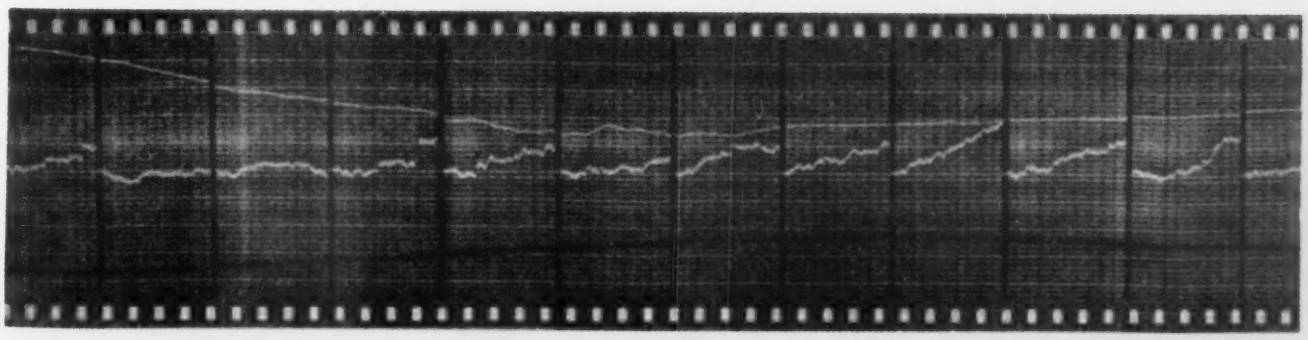


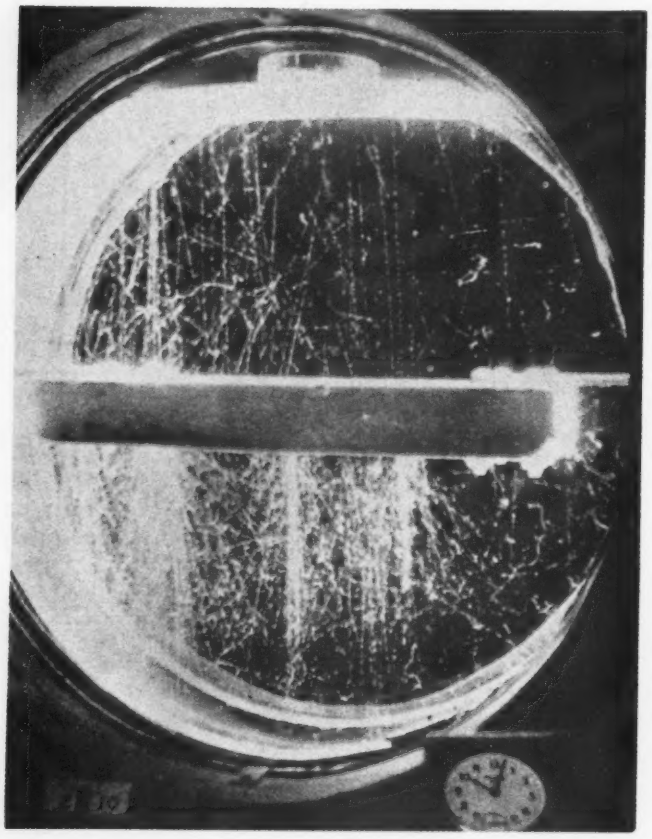
Figure 2: Shower curve (also called the "Rossi curve") obtained at an altitude of about two miles with an arrangement of four counters. Note the great increase resulting from the superposition of the first two centimeters of lead, and the sharp maximum, followed by a gradually sloping decline.



Compton, Wollan, and Bennett

A twelve-hour record of cosmic ray ionization obtained with a specially designed ionization chamber and electrometer. The wavy white line records the position of the electrometer needle; the heavy black line records the barometric pressure; and the fine white line is a record of the temperature. At the end of each hour the needle returns to its zero position. The dark vertical lines mark off the hours. A sudden jump of the electrometer needle indicates a burst of ionization.

afterward the work was resumed with renewed vigor. The intensity of the cosmic rays was measured deep in mines, under large bodies of water, and high in the atmosphere. When the graph of the intensity of the cosmic rays was plotted against the thickness of the material through which the rays had penetrated, it was seen that the intensity rose to a maximum at the middle altitudes, after which it decreased steadily. Therefore the cosmic rays were shown to be of such a nature that they increase in number for a time after entering the atmosphere, after which time they begin to be absorbed. Several other consequences of these investigations of cosmic ray intensity soon became evident. For one thing, the rays were shown to consist of at least two components: one hard and the other soft. The hard component was found to be very penetrating, since it is



Corson and Brode

Extensive atmospheric (or Auger-) shower containing many high-energy electrons. Note the parallelism of the vertical tracks, which indicates that the shower must have originated high above the apparatus.

found as far down as any measurements are made. On the other hand, the soft component was seen to be not too penetrating since the amount of it present was found to be almost negligible at great depths. It must be realized that the latter component is soft only relative to the hard component: actually the soft component is 1000 times more energetic than the most energetic gamma rays from radioactive substances. As another result of the measurement of cosmic ray intensity it was demonstrated that the cosmic rays are absorbed according to the following equation:

$$I_x = I_o e^{-\mu x}$$

where I_x is the intensity of the rays after having penetrated to a depth x of material, I_o is the original intensity, e is the natural base of logarithms, and μ is the linear absorption coefficient of the material. Often the above equation is expressed in the form:

$$I_x = I_o e^{-(\mu/p)(px)}$$

where $\left(\frac{\mu}{p}\right)$ is the mass absorption coefficient of the material and (px) is the weight in grams per cm² of a cross section of the column with depth x. Since the absorption of the cosmic rays depends only on the density of the absorbing material, it is customary to express the thickness of the material in terms of an equivalent thickness in meters of water.

The only rays which are absorbed according to the above equation are electromagnetic waves, or rays of particles such as electrons which do not change their properties in traveling through matter. In order to determine to which class the cosmic rays belong, it was necessary to find out whether the intensity of the cosmic rays varied with the latitude. If the cosmic rays were charged particles, they would, in effect, constitute a current of electricity because of their great speed. Therefore, when the cosmic rays approached the magnetic field of the earth, they would be deflected in a direction perpendicular both to the earth's magnetic lines of force and to their own velocity. The energies which the cosmic rays must possess as a consequence of their great penetrating power are of such magnitude that, even if it were true that the cosmic rays were charged, the earth's magnetic field could affect them appreciably only if the rays were in it for long periods of time. Therefore, it was deduced that if cosmic rays were charged, they must have their origin outside of our solar system. Furthermore, measurements indicated that the intensity of cosmic rays does not vary as we move through space; hence the distribution of the cosmic rays is presumed to be homogeneous throughout the universe. Since the magnetic lines of force of the earth run between the North magnetic pole and the South magnetic pole, cosmic rays approaching the equator would be deflected unless they had energies in excess of 2×10^{10} ev. (electron volts) while those in the polar regions could approach the earth unhindered. Consequently, as counters were moved further and further away from the equator the intensity of the cosmic rays should increase if the cosmic rays were actually charged particles. The graph of Clay's measurements is shown in Figure 1. You will notice that at latitude 40° the curve levels off, showing that although the geomagnetic effect of the earth continues to decrease beyond this latitude, there is no corresponding increase in the intensity of ionization produced by cosmic rays. This condition exists because the cosmic rays must overcome the magnetic effect of the sun before they can ever reach the earth. Hence, cosmic rays below an energy of 6×10^{9} ev., which energy corresponds to that needed to reach the earth at 40° latitude, are not even able to penetrate the sun's magnetic field. A. H. Compton and J. Clay showed that this actually was the case by measuring the intensity of cosmic rays in a number of global voyages. Therefore we know that cosmic rays consist, at least in part, of changed particles. There is another important consequence of the geomagnetic effect of the earth on cosmic rays; namely, positive cosmic rays should be deflected towards the east, while negative cosmic rays should be deflected towards the west. Hence if we set up coincidence counters in the proper manner, we will be able to determine whether more cosmic rays seem to come from an easterly or

(*Continued on page 168*)

The Radio Society of M.I.T.

By PETER JOHNSON, '48

ONE of the many student organizations at the Institute is the Radio Society, which owns and operates a complete amateur radio broadcasting and receiving station with the call W1MX. It is open almost any evening after five o'clock, and any student or faculty member of Technology is welcome to drop in for a chat over the air with amateur radio operators in the vicinity, and sometimes it is possible to converse across the country or across the ocean. Members of the Radio Society talked to Hawaii and Japan before the war (it is not recorded whether the communications were in Japanese), and reached Honolulu as early as 1922, when radio was in its infancy.

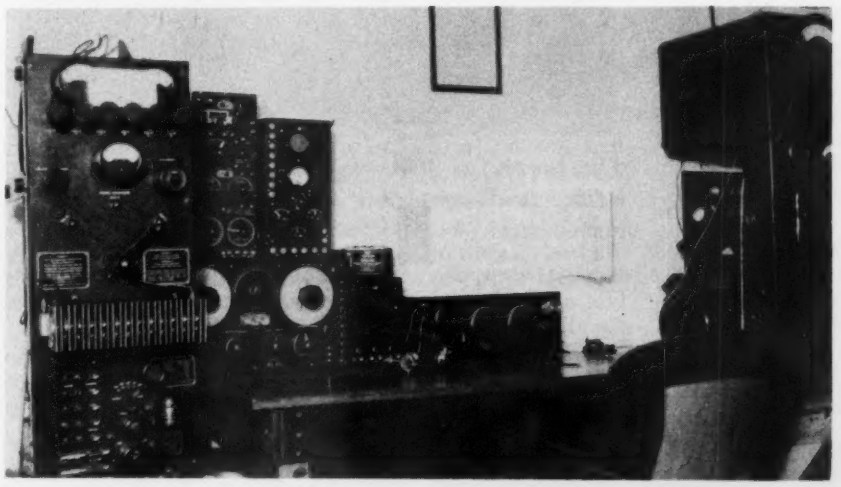
In addition to operating several transmitters for radiotelephone transmission, the Society is a member of a nation-wide and world-wide network of amateur radiotelegraph stations working together to distribute messages to all parts of the world through the dots and dashes of the international code. Anyone may leave a message to be transmitted by the Radio Society to any point in the United States, and it will soon be sent on its way toward its destination with the speed of light. The Radio Society and all other amateur radio stations perform this service absolutely free, as a courtesy extended by amateur radio to the general public.

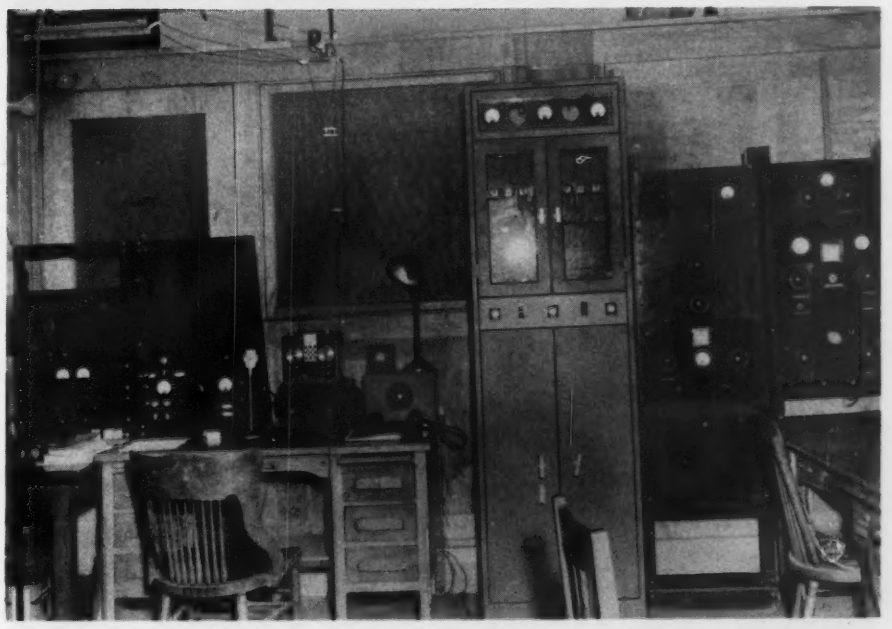
As an amateur radio organization, however, the M. I. T. Radio Society is especially interested in training others to become proficient amateur radio operators. Since one of the provisions for obtaining a Federal amateur operator's license is to be able to transmit and receive the radiotelegraph code, the Society has an automatic code practice machine, adjustable for any speed, with which any Society member can practice, and regular code classes for beginners are held twice a week.

The oldest national radio society is the American Radio Relay League, which is the largest amateur radio organization in the world. But in 1909, years before the world-renowned League had come into existence, the Radio Society of M. I. T. had been founded. It was the first college radio society in the United States and probably one of the first radio societies in the world. That was long before the advent of the vacuum tube, and the M. I. T. Radio Society built a spark-gap transmitter which, it is reported, did a far better job of generating an audible noise than a radio-frequency signal.

During the course of its existence the Radio Society went through both good and bad times. Shortly after the first World War it had reached a maximum membership of a hundred and seventeen. A few years later it had dwindled so that *Technique*, the M. I. T. yearbook, forgot to mention its existence. During the first World War it disappeared from existence altogether, because of a Federal ban on amateur radio activity. After intensive efforts by the American Radio Relay League, amateur radio was re-established after the war, and the Society promptly went back into operation. Before the war the Federal Communications Commission had come into existence for the purpose of licensing amateur and commercial

Station 1MX around 1920. The left-hand piece of equipment is a quenched-gap spark transmitter, used before effective vacuum-tube transmitters had been developed





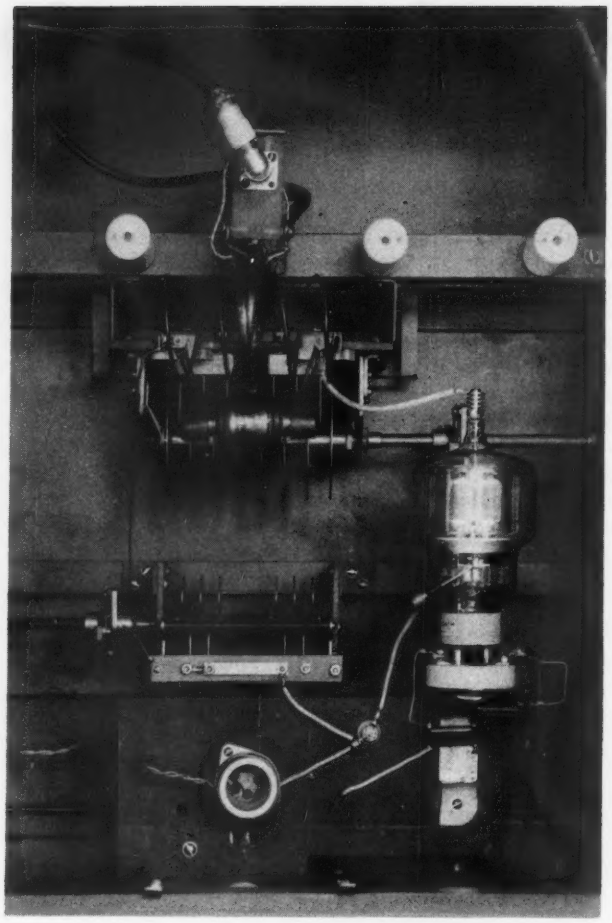
W1MX's wartime home in Building 10

stations. The Radio Society received the call 1XM, which was eventually changed to W1MX, the present call of the Radio Society. The members of the Society responded enthusiastically to the new licensing system, and as early as 1917 there were fifteen commercial and twelve amateur operators in the Society at M. I. T.

After the first World War, however, the Radio Society experienced many obstacles in getting on its feet. Among other things, the Society could not find room at Technology in which to set up its transmitters. Finally the Superintendent of Buildings offered the Society the use of a cavernous room standing at the base of the smokestack at the power plant of M. I. T. It had quite a few disadvantages. It had no windows and no light; the floor was low and usually swamped with water. There was no way in which an antenna could leave the building, and so the members of the Society went to work on the wall, drilling a hole through it with a star drill. One of the members of the Society was Hiram Maxim, Jr., the son of the inventor of the first World War Maxim gun. During the drilling of the wall, Hiram had been on the outside, working inward. When the hole had been completed, he stooped to look through it, just as someone inside decided to blow the stone dust out of the hole. Luckily, Hiram did not lose his eyesight. The hole in the wall remained on the side of the power plant.

Eventually Building and Power took pity on the fledgling society and offered it a room on the second floor of the foundry in which to operate, and the members of the Society erected an antenna from the top of the chimney of the power plant to the roof of the foundry. No one seems to know who climbed the smokestack to fasten the aerial at its top.

Just before the last World War, until May 1942, the Society had a "shack" just west of the Barbour Field House. It was furnished in a super-deluxe manner, with powerful transmitters operating on every amateur band and a separate antenna for each transmitter. All of the transmitters were installed behind a wire cage, so that they could be operated with no chance of exposure to the voltages necessary to operate them. During the war, however, the Government once again called a halt



The powerful 304th transmitting tube used in the final amplifier of the new kilowatt transmitter

to amateur radio transmissions. The station remained idle until May of 1942 and then was finally dismantled for the duration of the war.

Since the war the former members of the Radio Society and a host of new members have been working hard to make W1MX the powerful station that it was before the war, but the dollar dues collected by the Society could not furnish the necessary equipment. Therefore the Electrical Engineering Department of M. I. T. generously lent the Society the final stage of a powerful kilowatt transmitter. This has been the basic piece of equipment around which the postwar station has been built.

At present the Radio Society has just started operating the kilowatt transmitter on the twenty-meter radiotelegraph band, on which it should be possible to talk around the world. In addition, a radiotelephone transmitter has been built for the ten-meter band, on which communication is usually limited to around fifty miles, but occasionally has been known to occur over thousands of miles. A midget portable transceiver (combination transmitter and receiver) is in operation on the two-meter band, and every evening some

(*Continued on page 162*)

One of the receivers gets an overhauling

Color Photography

By KENNETH WIBERG, '48

PART II. THE PRINT

IN the past, one of the chief factors for the lack of interest in color materials in the case of amateurs, was the difficulty of obtaining color prints at a reasonable price. The disadvantages of having to display one's color photographs as transparencies is at once evident. However, the situation is now much improved. The production of color prints of fair quality is hardly more difficult than the production of the ordinary black-and-white prints. More satisfactory prints, of course, require more elaborate techniques, but they can be carried through in any average darkroom.

Ansco "Printon" is an example of a color printing paper which can be developed in a manner very similar to that used for the development of black-and-white film. This material is constructed very much similar to Ansco-Color film (*cf.* Part I). It is exposed in the same manner as black-and-white paper, except that it must be particularly carefully shielded from extraneous light, as it is a panchromatic emulsion. If a certain amount of color correction is desired, a series of filters for that purpose is available. The material is developed in an ordinary developer, placed in a short stop, developed in a color developer, bleached and fixed. The simplicity of this method is its chief advantage, because, although the color rendition is not too bad, it is much poorer in most cases than the results obtained by using one of the following methods. (The observations on the quality of this material are the author's alone — many people do like the material, but the author has yet to see a truly satisfactory print made by this process.)

Many methods have been proposed for the obtaining of color prints on paper. Nearly all of these, however, require the use of separation negatives, and therefore we will discuss these first. One of the simplest methods of obtaining color separation negatives, a set of three negatives — one of which photographs the blue in the scene, another the red, and the third the green — is by the use of a color camera.

M_1 and M_2 are two-thirds and one-half silvered mirrors respectively, *i.e.*, they will reflect one-third and one-half of the incident light. P_1, P_2 and P_3 are blue sensitive, red sensitive and green sensitive emulsions. Thus it can be seen that the one-third of the light incident on M_1 will be reflected and the blue of same will be photographed by P_1, one-half of the remaining light, or one-third of the original light will be reflected by M_2 and the red in same will be photographed by P_2. The remaining one-third of the original light will then pass through M_2 and the green in same will be photographed by P_3. Thus the three separation negatives are made simultaneously. The only disadvantage to this method is that the effective emulsion speed becomes very low, and therefore lone exposures are necessary. Also, the cameras are rather expensive (about $325 for the inexpensive models).

However the separation negatives can be made in a less expensive manner. Three separate exposures on three pieces of film through A, B, and C_5 filters can be made, without moving the camera. In this way, if the correct filter factors are followed, a correctly balanced set of separations will be obtained.

The third, and the most practical method of obtaining color separations, is through the making of separations from a color transparency. This is a simple process, provided care is taken to get the separations balanced. Perhaps a description of this process would be in order

1. The color transparency is placed in the enlarger, which has been made light-tight. Next to the transparency is placed a gray scale, and a green (Wratten F) filter is placed over the lens. The illumination incident upon a piece of white paper placed on the easel is adjusted to a definite level (previously determined by experiment) by stopping down the lens. A ten-second exposure is made on the film used, which must of course be panchromatic. The film is developed to a gamma of 0.7 in any non-staining developer. (A p-phenylene diamine, or glycin, developer should not be used.) The film is then placed in the enlarger and the density of one of the steps on the film is determined. The correct exposure through the F filter is then determined by using the following formula:

$$\log E=\frac{1}{\gamma}d_b-d_a+1 \quad [\log E=\frac{1}{\gamma}d_b-d_a+1]$$

where E is the exposure, d_b is the density of the step on the projected film, and d_a is the density of the same step on the gray scale. γ is the gamma to which the film was developed.

A microphotographing instrument

The transparency is then replaced in the enlarger, and the separation through the red F filter is then made. The F filter is replaced by the green N filter and an exposure of $\frac{f_N}{f_F}E$ is made on another piece of film. Finally the N filter is replaced by the blue C_4 filter and an exposure of $\frac{f_{C4}}{f_E}E$ is made on the third piece of

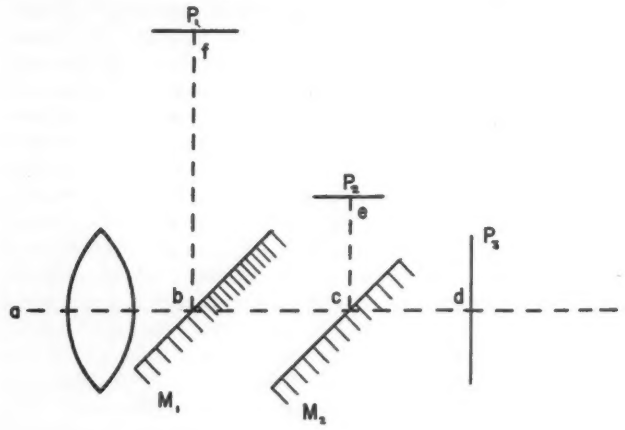


Fig. 1

film. (f_N, f_F, and f_{C4} are the filter factors for the N, F and C_4 filters corresponding to the film used.) The green filter film is developed for the same length of time as the red filter film, while the blue filter film is developed twenty-five per cent longer than the others. The film is then fixed, and washed thoroughly as usual, and dried. If these directions were followed carefully, a perfectly balanced set of separations would be obtained.

This sounds like a good deal of work, and it is. But it is much easier than trying to make a fairly good set of separations and correcting them later. The only piece of equipment necessary, which is not commonly found in the darkroom, is a densiometer — but inexpensive densiometers have been placed on the market, the Haynes model being quite good for the purpose — and these instruments have the added advantage that they can also be used as printing exposure meters.

More advance workers in the field often resort to masking in an attempt to try to improve color rendition and saturation. But for the amateur's purpose, unmasked separations will usually be perfectly satisfactory. If, however, you would like to try masking, you are referred to Dr. Friedman's excellent book, "History of Color Photography."

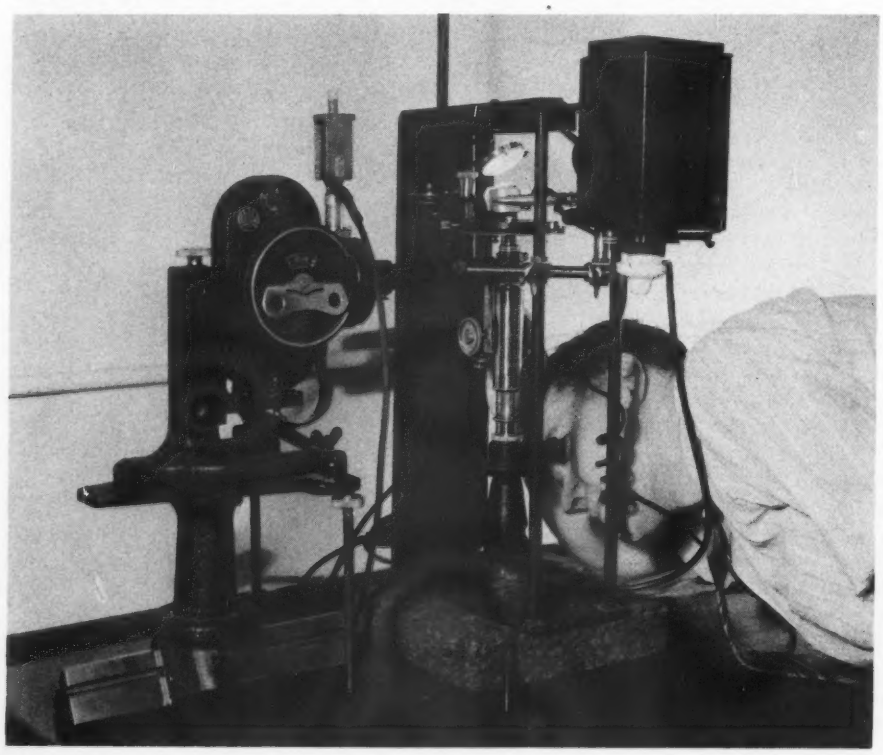
After the separations are made, the real work of making color prints can begin. As the Eastman Dye Transfer process is the most practicable method available for the amateur at this time, this method will next be discussed.

The exposure is first determined by the following procedure: the easel illumination is adjusted to five-foot candles at $f:4.5$. A gray scale is placed in the enlarger, and the enlarger is stopped down to $f:11$. A ten-second exposure is made through the back of the Kodak Matrix Film, and this is processed according to directions (similar to the development of black-and-white film, except that a hot water rinse is added). The matrix is dyed cyan, and transferred to a piece of mordanted paper. The step on the gray scale corresponding to the density which was just sufficient to produce a noticeable color is noted, and the density of same is determined. The red filter negative is next placed in the enlarger and the density of the highlight is determined. The correct exposure is determined by the following formula:

$$\log E = d_b - d_a - 1$$

where d_b is the highlight density, and d_a is the gray scale density. This is identical with the formula used to determine the exposure for the separation negatives, except that the $\frac{1}{\gamma}$ term is dropped.

Adjusting the apparatus used to take color microphotographs of textiles



If the three separation negatives are correctly balanced, the same exposure is used for each of them, If, however, they are not so well balanced, a certain amount of correction can be applied. Further information on this point is available from the Eastman Kodak Company by requesting their booklet "Color Prints with the Dye Transfer Process."

The exposed matrixes are then developed according to directions provided with the film and dried. Then all that remains is to dye the three matrixes and to put them down on paper. The matrix made from the blue separation is dyed yellow, the green separation is dyed magenta, and the red separation is dyed cyan. The dye on the matrixes is transferred to a piece of paper mordanted with aluminum hydroxide by placing them in contact with the paper. The final result is a three-color print, which is usually very satisfactory after a little experience with the method is acquired.

Other methods are available, but this method is more simple, is

(*Continued on page 174*)

THE SUN'S SONS

By PETER B. NEIMAN, '49

Fourth in a series of articles on Elementary Astronomy

WE on Earth are members of a unique celestial family. It is the Solar System, consisting of one parent star, nine planets, moons, comets, meteors, and asteroids. From a biological and psychological standpoint, the most important of the offspring of our parent Sun are the planets, for only on them may life exist. For this reason, let us discuss the planets in some small detail, and also find out where and when they may be observed in the night sky.

The planets describe approximately elliptical paths about the Sun, with the Sun as one focus of the ellipse. Proceeding radially outward from the Sun, they are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

Mercury, the smallest of the planets, 3.5×10^7 miles from the Sun, has a diameter of only .39 times and a volume .06 times that of the Earth. It is also the fastest planet, traveling at 29.7 m.p.s. and going around the Sun in 88 days. It is not much larger than our Moon, and, like the Moon's behavior with the Earth, it is so tightly held in the gravitational grip of the Sun, that it rotates about its axis only once as it goes around the Sun, thus eternally presenting the same face to the Sun, which, because of its nearness, makes this face hot enough to melt most of the metals found on its surface. In contrast, the other side, which never receives sunlight, is well below the freezing point of water. Comparison of the quality of light reflected from its surface with light reflected from various Earth substances indicates that its surface is mostly volcanic ash.

Venus, almost as large as the Earth, is next. It is 6.63×10^7 miles out, travels at 21.7 m.p.s., and revolves in 226 days. It is the most brilliant of the planets, and the first one to be far enough out to hold an atmosphere. Its atmosphere is mostly ammonia, giving Venus its beautiful golden color, but unfortunately making the planet quite hostile to life.

Both Mercury and Venus, being in between the Earth and the Sun, can only be seen when the Sun is visible, never in the night sky. Since the blinding glare of the Sun makes daytime observation almost impossible, the only time left is twilight or sunrise. It is for this reason that the ancients called the pair Evening (or Morning) Stars.

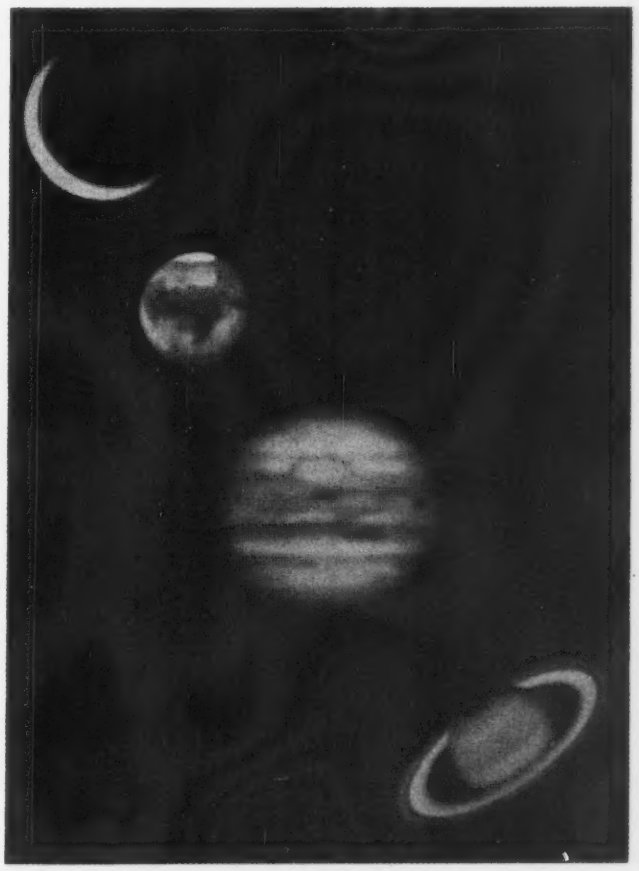
During the month of February, Mercury will not be in a favorable position for observation, but Venus will be a brilliant Morning Star, rising about 4:30 A.M. It will shine in the constellation Scorpio, in the southeast, and may be followed right up to and into the sunrise.

Next is the Earth. It has a diameter of 8,000 miles, travels at 18.5 m.p.s., 9.2×10^7 miles from its parent. Its period of revolution determines the elementary astronomical time unit, being defined as one year. It may be seen at any time of day or night by looking up, down, or sideways.

Beyond the Earth come the outer planets, encircling the Earth as well as the Sun. First of these is Mars, with its two moons, 1.4×10^8 miles away. It takes 1.88 years at 15 m.p.s. to go around the Sun. It is about half as large as the Earth, and about a tenth as heavy. Of all the planets, Mars most closely resembles the Earth in temperature range, going from about 55° F. down to arctic temperatures. Its surface is probably volcanic ash. Some scientists believe that there is vegetation on Mars, hence the possibility of higher forms of life. Its famous canals, however, are the works of nature, and not Orson Welles.

During February, Mars will be too near the Sun for observation, but when it again becomes a night sky object, it will shine as a strikingly beautiful red body.

Out 428 million miles, next to the Red Planet, is Jupiter, with its nine moons. It is rightly named Jupiter (Zeus Pater, father of the ancient world), for it is



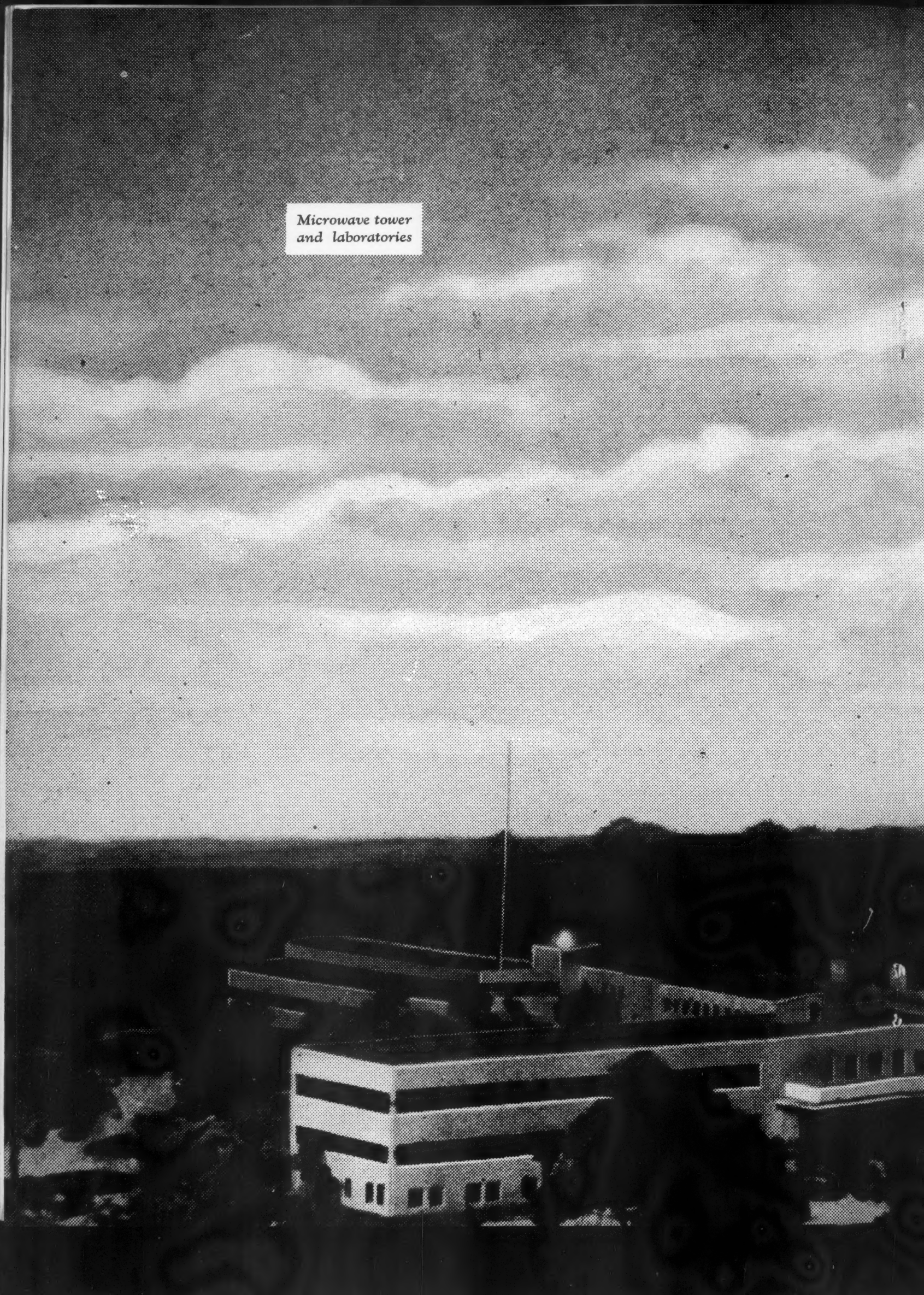
Four members of the solar system (top to bottom): Venus, Mars, Jupiter and Saturn

the largest of the planets. Twice the matter of all the other planets could fit inside this body whose diameter is more than a third of the way from here to the Moon. At 8.1 m.p.s., it takes 11.8 years to complete a Jupiter year. As we go farther out, the planets get colder, since their heat depends almost entirely on the Sun. Jupiter is −142° F., far too cold for life to exist.

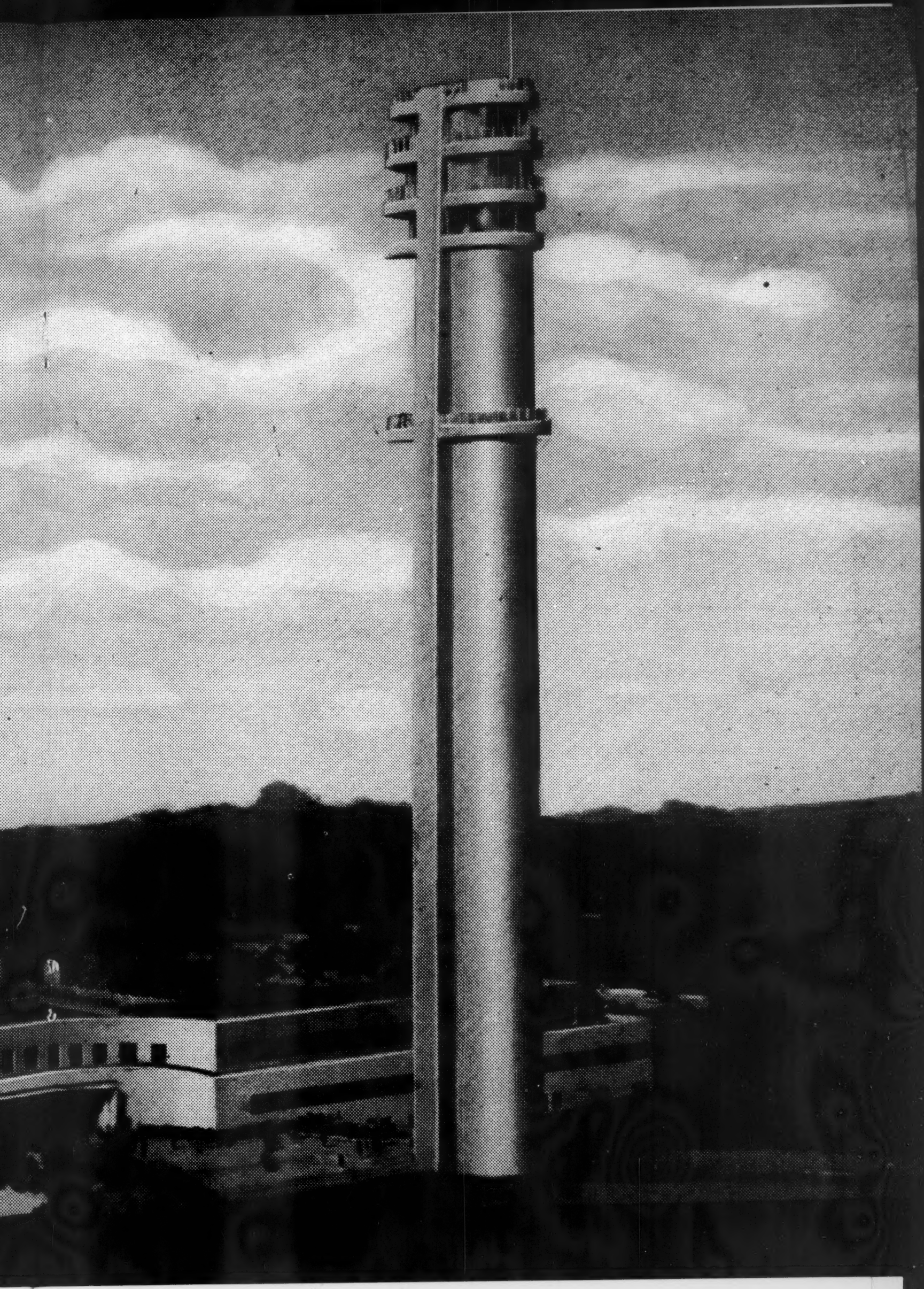
The King of the Heavens can be seen in the constellation Libra in the south sky. It rises about 2 A.M. at the beginning of February, and at about midnight towards the end of the month.

Next is Saturn, 8.77×10^8 miles away from the Sun, with also nine moons. It is smaller than Jupiter, in fact all the planets beyond Jupiter get gradually smaller with distance, just as the ones inside got larger as they approached Jupiter. (Mars is the only exception.)

(*Continued on page 174*)



Microwave tower and laboratories



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Can You Do It?

THE SIXTH IN A SERIES OF MONTHLY BRAINBUSTERS

THIS MONTH: Two Easy Ones—But Look Before You Leap!

Problem 1: Amoeba reproduce by fission, splitting into two amoeba which in turn become four, then eight, and so on, the process occurring at regular intervals.

Suppose we experiment with one of these remarkable animals. We place him in an empty tumbler and watch him begin to raise a family. After three minutes there are two amoeba sitting in our crystalline laboratory. After two hours, the tumbler is full, and we stop the experiment.

As a further experiment we now take two amoeba and place them in another empty tumbler and time their reproduction rates. After three minutes, four amoeba are in the glass. If we allow the process to continue, how long, altogether, will it take the two amoeba to fill the tumbler?

Problem 2: Each asterisk in the following division problem stands for a single digit. Given only the information shown below, can you deduce the dividend and the divisor?

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J. W. W.

(*Answers to last month's problems are on page 170*)

The Dragon's Den

Why Not More Scientists? . . .

It is now common knowledge that the United States is far behind Russia and England in current supply of scientific personnel. During the war, those European countries did not conscript their scientific and engineering students but, on the contrary, encouraged them with financial aid. Because the United States did not do this, various observers have mentioned figures as high as 155,000 as representing the shortness of the technical manpower supply. There is nothing, though, that we can do about the past; the reasons for our lack of foresight will not contribute to our future welfare. Therefore, we must see what can be done in the future so that we may assure ourselves of larger science reserve.

The Congress of the United States is now considering, or has considered recently, several bills designed to help our needs in this direction. All the bills are similar in purpose: the setting up of a National Science Foundation. The Foundation would have two functions; one would provide scholarships and fellowships to American citizens on the basis of talent, the other would help to finance very necessary basic research in colleges, universities, and other nonprofit research organizations. The former activity is an extension of activity now carried out by private foundations and corporations, as well as schools. However, their work has thus far been limited and many people who have the *talent*, but not the financial background, are unable to study the six or seven years which are required for advanced research in the basic physical sciences — chemistry, physics, and mathematics. The long education prerequisite to research is and has been a block to its unlimited expansion. Naturally, the problem of research raises certain questions. If there is to be long-range programs of scientific government-supported education, then what will those who receive its benefits do at the end? Will they go into industry and develop "new and better things for better living . . . "? Or will they remain in a school or research institution and work at that mysterious field called "basic research"? The second function of the National Science Foundation is designed to relieve a modern worry on just this subject. Present estimates indicate that about ninety-five per cent of the money spent on research is devoted to the cause of industrial research which is largely a developmental type of work — radar on the principle of the microwave tube, new and better cars for the automobile buyer, bigger and faster airplanes on the basis of a few fundamentals of gaseous flow and gaseous compressibility. Some scientists feel that at the present rate of allocation of funds, industrial and applied research will soon outstrip very materially the principles available for major developments, and the result will be a more or less static condition of scientific advance. The National Science Foundation will help to finance "basic research" in nonprofit institutions, trying to assure us of a steady and ever-increasing flow of basic principles on which to base industrial research.

There are three bills concerned with this subject. In the Senate, the Kilgore Bill has already passed, while the Magnuson Bill is either still in committee or has been bypassed. Representative Mills has introduced a corresponding bill into the House of Representatives. These differ on two main points: administration and disposal of patentable discoveries. One establishes a civilian board for control, while the other suggests a single man with an advisory board of prominent scientists. These differences seem trivial in view of the present necessity for the activation of the plans presented therein.

The cost of the plan under a system would be trivial compared to our national military expenditure: some one hundred and twenty millions of dollars for five years of operation, during which time there would be annually presented six thousand scholarships and three hundred fellowships.

Vannevar Bush, in his book, "Science, the Endless Frontier," stated that ". . . there must be more — and more adequate — military research in peacetime." Whether or not you agree with this statement, it seems to be a need under the present setup of the world, and, if it is to be carried out, legislation must be enacted.

We at Technology are the engineers *and* scientists of the future. In this capacity, we *must* concern ourselves with the problem of properly implementing the science of the future with enough workers so that it may be sped along its destined path — so that we may gain and share in the future of mankind!

E. M. K.

NAVAR

(*Continued from page 147*)

the ground does not depend on reflected radar pulses. Instead it uses pulses automatically transmitted over a common wide band by the planes whenever their receivers pick up any radar pulses. The responses are received over a directional antenna on the ground rotating in synchronism with the radar beam. They are subsequently fed into a different receiving set than that used for the normal radar. Such a selection is called comprehensive beacon radar (CBR).

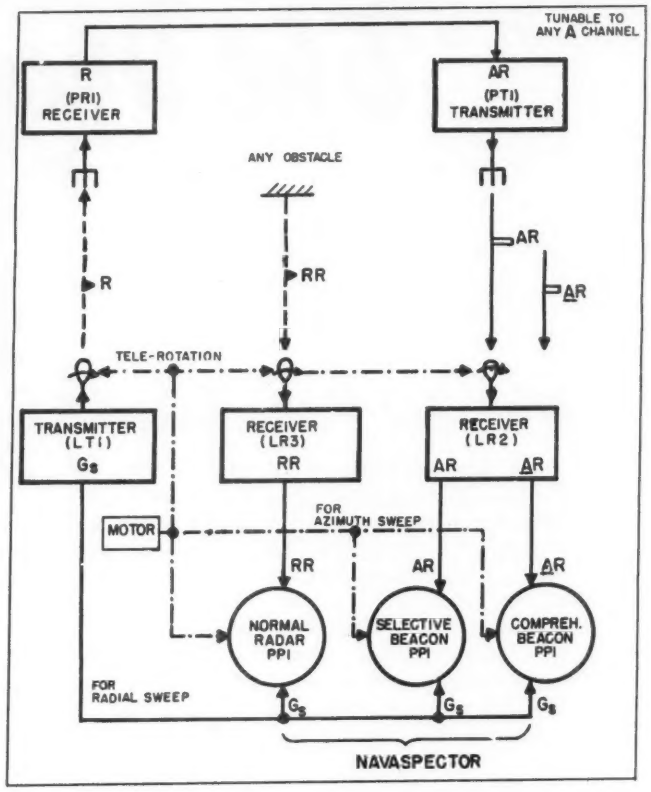
The selection of the planes on the PPI scope can be further limited in number to only the planes tuned to the particular ground station. This is done on the selective beacon radar (SBR) scope by having the plane also respond over its A band whenever it receives an R pulse from its own ground station.

Under the beacon responder techniques, the plane's transmitters are connected with barometric altimeters which modulate the responses slightly according to altitude. In this way the ground station gets fairly accurate altitude information which it can use to have PPI scopes for various general altitudes.

The rate of rotation of the radar beam and the directional receiver in phase with it varies from station to station. Therefore a given ground station will not continually pick up either the reflected or response-transmitted pulse of another ground station.

In this Navaspector system one ground receiver can receive both types of response pulses, and consequently the ground station must only be equipped with two receivers and one transmitter. The plane must have a receiver and a transmitter.

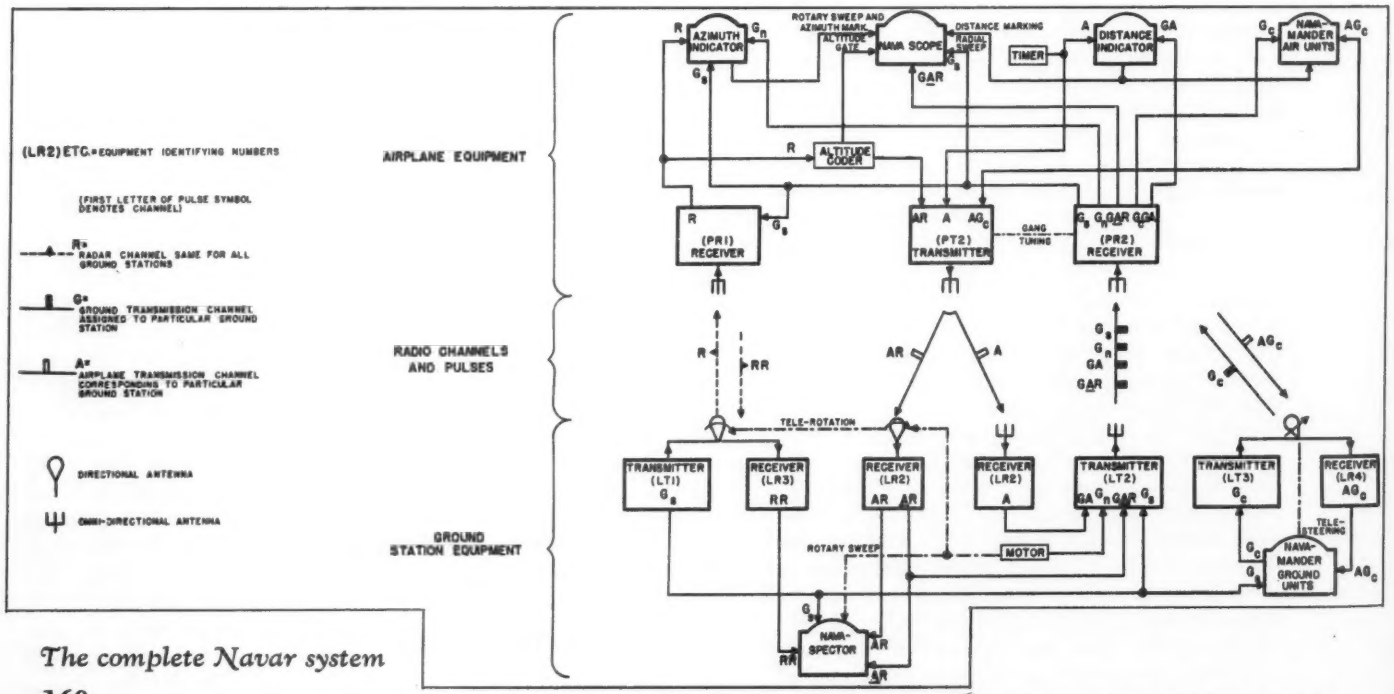
The fourth component of the Navar system is Navamander. This function depends on the plane's having Self-Distance equipment and derives most of its usefulness when the ground station has the Navaspector scopes indicating the location of planes in the surrounding area. The basic purpose of the Navamander system is to enable the ground station to communicate with the planes non-verbally; that is, to send standard commands and questions to the planes by coded systems of pulses over channels other than those useful for audio frequencies.



Navaspector function

The first step in such an operation is to be able to pick out a particular plane and have an arrangement whereby that plane is the only one able to receive the message. For such a system all planes are located with respect to a ground station by polar coördinates. The plane's azimuth and distance from the station give it an exact location. To reach a certain plane, a ground station sends out directionally a number of times two pulses, G_c, with the interval of time between the two pulses standing for some message. But this only locates the direction of the selected plane and any plane on the radial line might get the message. The arrangement by

(*Continued on page 164*)



The complete Navar system

NUMBER 5 OF A SERIES

Newsworthy Notes for Engineers

Why Condensers now live longer

Testing and setting standards for materials is a vital part of production at Western Electric.

Take, for example, the tissue paper —about 1/10 the thickness of a human hair—used as insulation between the turns of aluminum foil in millions of "paper" condensers for the Bell System.

Condenser life is generally in direct proportion to the quality of tissue used. In studying effects of differences in chemical composition, fibre structure, thickness, pinholes and other properties to set a standard of quality, engineers found intrinsic variables so great that a method of rating had to be developed.

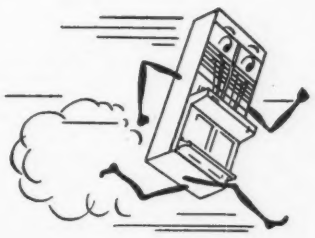
They solved this problem by making sample condensers using each type of paper and checking them at high temperatures and high voltages to determine life expectancy.

Correlating results of these accelerated life tests with manufacturing data led to improved paper making methods—paper manufacturing machines of new designs—increased production of the right kind of paper—longer-lived condensers.

It's hard to hurry a Switchboard

One of the major problems faced by Western Electric engineers in the rush to make telephone switchboards *fast* —to meet unprecedented demands— is the complexity of manufacture involved.

A recent study of what it takes to make a certain much-needed type of manual switchboard installation consisting of ten operator positions will give you some idea of the complexity. Here are the principal items of apparatus required: 5,680 relays; 19,500 jacks; 15,000 lamps of various kinds plus their lamp sockets and mounting; 17,000 lamp caps of various colors and designations; 450 mounting plates of relays, condensers and resistances; 580 resistances; 550 condensers; 360 fuses; 691 jack spaces and a total of 1,071,000 conductor feet of wire and cable!



In spite of this complexity, Western Electric is speeding switchboards on their way. Production in 1946 of manual switchboards is expected to break a record of 16 years' standing.

Problem for *Production* Engineers

Easy? Not when it means providing machine capacity for welding a billion precious metal contacts per year —*five times* the previous maximum production rate! This problem was one of the most critical faced by Western Electric engineers in meeting tremendously increased demands for telephone equipment.

A pair of these contacts is required at every point in telephone circuits where current is interrupted in switching. They minimize "noise" in your telephone receiver. They're made of bi-metal tape—the contact surface is paper-thin precious metal, usually palladium. The balance is less expensive metal such as nickel.

By providing recently developed electronic control equipment and making mechanical improvements in the precision welding machines — which must cut off small pieces of tape, accurately position them on telephone apparatus parts and weld them securely—the engineers pushed operating speeds to a new high.

Result: only about two-thirds as many hard-to-get new welding machines were needed — a half-million dollars were saved — and welds of higher quality are being produced at the rate of a billion a year!

Manufacturing telephone and radio apparatus for the Bell System is Western Electric's primary job. It calls for engineers of many kinds — electrical, mechanical, industrial, chemical, metallurgical — who devise and improve machines and processes for large scale production of highest quality communications equipment.

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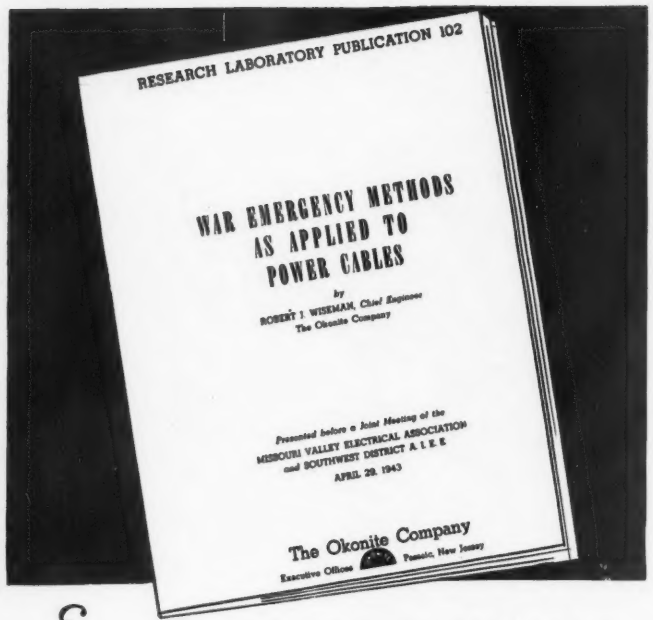
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The Okonite Company
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3722

THE RADIO SOCIETY OF M. I. T.

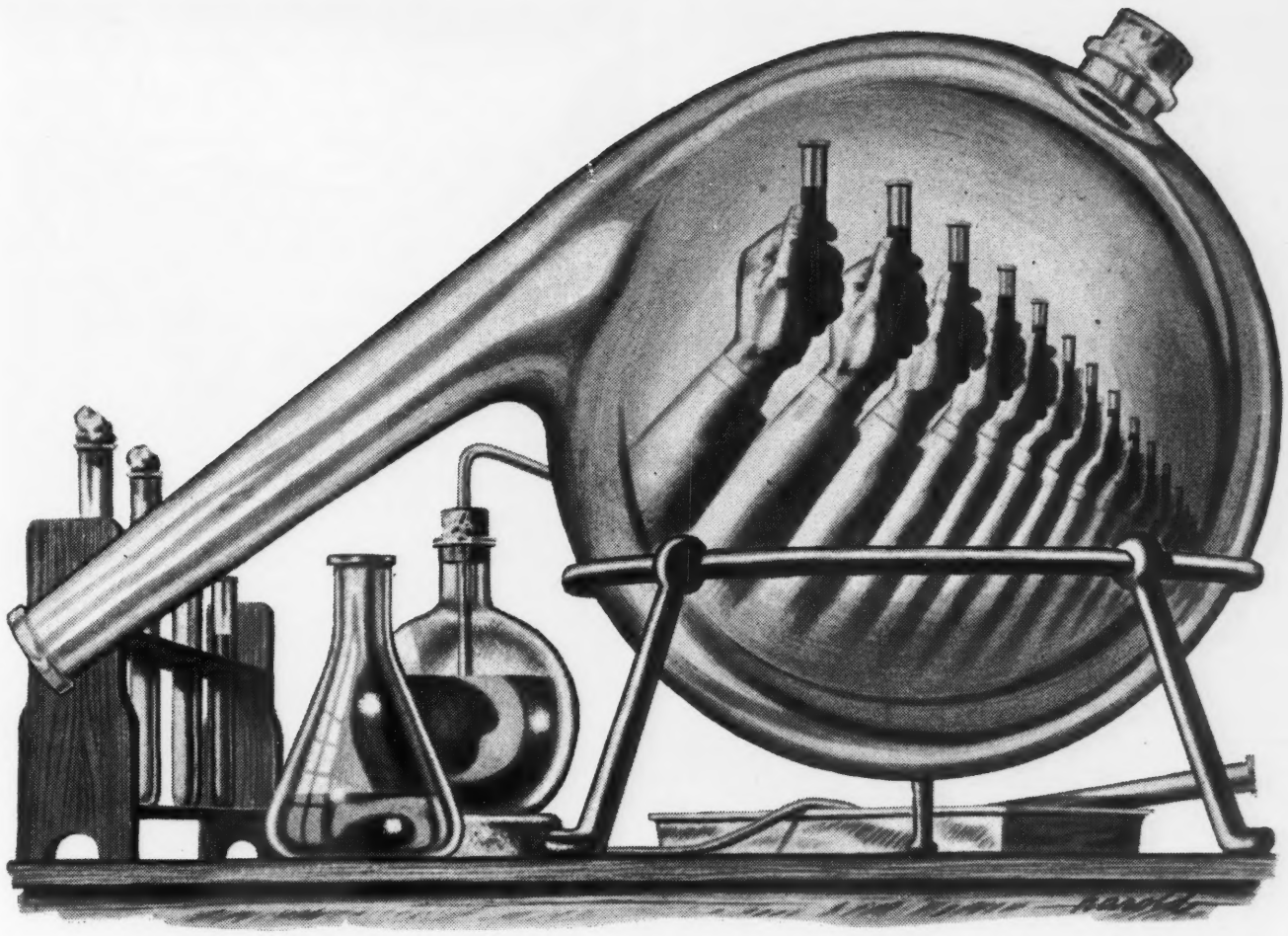
(*Continued from page 152*)

member of the Society can be seen chatting over it with other amateurs in the vicinity.

During the years that it has been in existence, the Radio Society has continually been in the forefront of the developments in radio. It was one of the very first amateur stations to transmit across the Atlantic, and thus received nation-wide attention in the 1920's. It reached Hawaii in 1923 and Japan in 1926, and within a few years the members of the Society were communicating with countries all over the world — with Chile, Austria, Germany, Poland, and Australia, among many others. In 1935 the Society coöperated with the Aeronautical Engineering Society of M. I. T. in equipping gliders with two-way radios. At present the Society is considering the very difficult task of setting up a television station so that it would be possible not only to talk over the air but also to see the person to whom one is talking.

Many of the members of the Radio Society are in Course VI (Electrical Engineering) because of their interest in electricity, but there are members scattered among all the courses offered by the Institute who, because they desire to learn something about the interesting field of radio and to learn a lifetime hobby to which they can turn in their spare time, have entered the Radio Society of M. I. T.

Operating the code-practice machine



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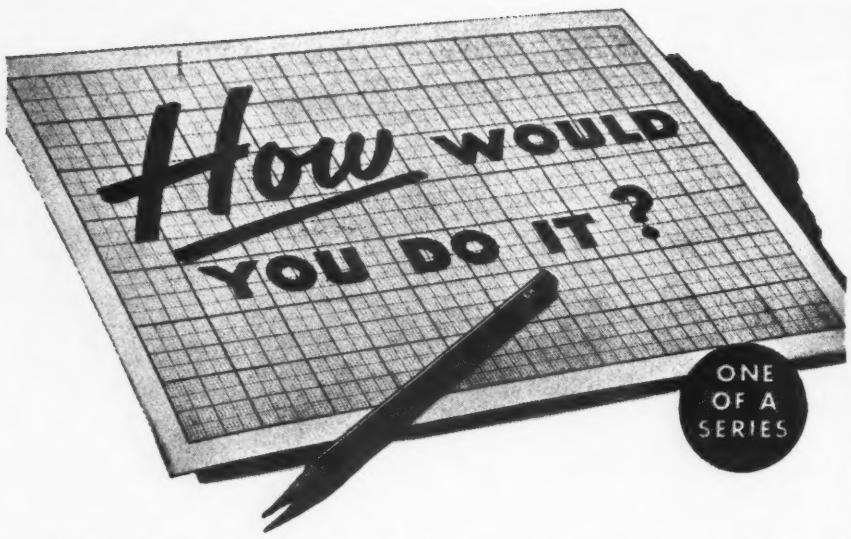
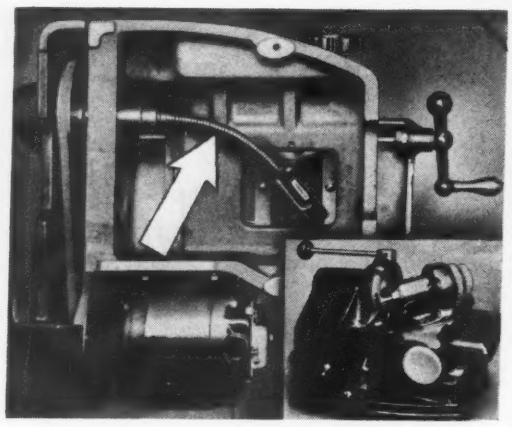
ESSO

Unending research work assures the high quality of all Esso Products



PROBLEM: You are designing a valve grinding machine. You have to provide a drive for the chuck that holds the valve stem. This chuck must be adjustable in three different directions. Your problem now is to devise a method of driving the chuck which permits these adjustments. How would you do it?

THE SIMPLE ANSWER: Use an S.S.White power drive flexible shaft to transmit power to the chuck. The shaft provides a positive, dependable drive that permits free movement of the chuck in any direction.



This is how one large manufacturer did it.

* * *

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NAVAR

(*Continued from page 160*)

which only the plane at the proper distance receives the message works thus: The ground station sends out omnidirectional pulses, G_s, through another transmitter at a certain regular rate per minute. The time interval between the sending of one of these G_s pulses and the first component of the two G_c pulses is set by the ground station and corresponds to the radial distance of the plane. Therefore the plane's receiver equipped with a distance gate receives only the coded pulses G_c sent in its direction and lagging the G_s pulse by the time which the plane's Self-Distance apparatus selects. Then it responds to the G_c pulses in a predetermined manner. If the G_c message is a request for the plane to identify itself or give its exact altitude, the plane's transmitter will accordingly send out in its A band pulses arranged in groups of two with the distance between the two pulses of any one group meaning some standard answer. This answer will then be picked up by the ground's directional receiver equipped to decode the message. If the ground station sends a standard command, the coded pulses will activate gear on the plane's instrument panel which by appropriate symbols will tell the pilot perhaps to rise one thousand feet or even to tune his two-way radio in on such and such a channel if the station wishes to talk to him.

To the pilots one very pleasant aspect of this arrangement is that they will no longer have to keep continually tuned to the common channel used by the airport from which they are receiving instructions. They will not have the nerve-racking duty of listening to everybody else's chatter just in case there should be a message for them.

The Navamander unit by itself requires two transmitters and one receiver on the ground and one receiver and one transmitter in the plane. But this does not consider the Self-Distance and Self-Azimuth equipment which the plane must have for the Navamander to function. When all these work in conjunction with Navaspector, the ground can watch for possible collisions and then identify the planes approaching each other and give them instructions on what to do. Most of this can even be done without the use of two-way radio communication — an attribute greatly to be desired since in general there

(*Continued on page 166*)

Television camera, receiving tube, all-electronic receiver and radio relay equipment —are the result of pioneering and research at RCA Laboratories.

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From the scene of action—to your own living room—these RCA developments based upon research at RCA Laboratories mean *television at its finest:*

RCA Image Orthicon Camera sees whatever the human eye sees, even in the light of a match! Sports events on cloudy days or in twilight do not fade because this super-sensitive camera eliminates the need for strong lighting.

RCA Mirror-backed Kinescope—searchlight brilliance for home television. All the lifelike realism and detail caught by the RCA Image Orthicon Camera is reproduced by this new receiving tube that loses none of the original brilliance.

RCA Victor Television Receiver—with the new RCA exclusive "Eye Witness" feature that "locks" the picture, keeps it bright, clear—as steady as a picture on the wall.

RCA Radio Relay equipment enables television stations to broadcast events taking place far from the studio, and eventually may link television networks. In television, as in radio, Victrola* radio-phonographs, records, or tubes, if it bears the name RCA or RCA Victor, it is one of the finest instruments of its kind science has achieved.

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Radio Corporation of America, RCA Building, Radio City, New York 20 . . . Listen to The RCA Victor Show, Sundays, 2:00 P. M., Eastern Time, over NBC. *"Victrola" T. M. Reg. U. S. Pat. Off.

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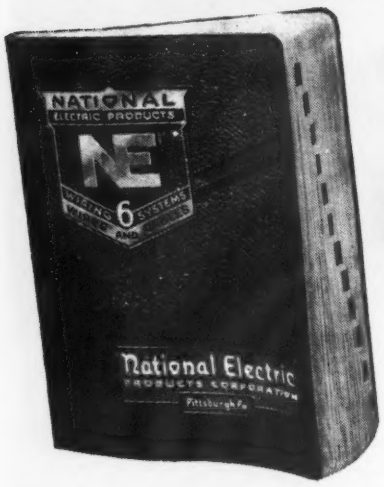
Attention ENGINEERS!



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National Electric
PRODUCTS CORPORATION
Box 897 — Pittsburgh 30, Pa.

NAVAR

(*Continued from page 164*)

is more chance for mistake and misunderstanding with verbal messages than with visual ones.

The last semi-independent unit in Navar is Navascope. Basically it is a method for transmitting to the plane information collected by equipment similar to Navaspector and having it displayed there on a PPI scope. This is all done with a minimum of equipment in the plane, and is only dependent on the plane's having Self-Distance and Self-Azimuth information.

Quite naturally the ideal form for flying safety calls for a map-like display in the plane of all the planes roundabout. Radar with its rotating antennas, etc., is bulky and heavy, and such air-borne units decrease the plane's pay load considerably. But if the basic scanning work is done on the ground where size and weight are not so important, and it is still possible to get to the plane a display which clearly identifies the particular plane and also displays all planes within the vicinity, then a great deal has been accomplished.

In Navascope the ground station sends out directional radar pulses and receives answers from the planes with pulse response transmitters. The selection here is the same as that of the CBR scope in the Navaspector function showing all planes with beacon responder apparatus regardless of whether they are tuned to the same station. It does not account for "stranger planes" (ones without response equipment). But they can be covered by the ground station with Navaspector. This way the plane has a clearer, more understandable scope, and the ground can give warning if any "stranger plane" is likely to cause a collision.

In Navaspector the system of pulses, AR, received at the ground station in answer to its R pulses stands for the location of planes. These pulses activate a cathode ray tube as they are fed into it. In Navascope these AR pulses are transmitted to the plane (GAR pulses) where they are then fed into a cathode ray tube. However, they must be properly oriented there. To do this the ground station sends out omnidirectionally pulses, G_s, in its G band in exact synchronism with its search radar pulses. At the plane the time interval between the arrival of a G_s pulse and a GAR pulse is proportional to the distance of the object. Thus it is possible in the plane to determine the radial distance from the center of the scope that the blip belongs. The ground station sends out another pulse, G_n, in its G band every time its directional radar points north. By gauging the time interval between a G_n pulse and a GAR pulse the azimuth of the blip on the scope can be determined.

The pilot gets a clear indication of just which blip on the scope stands for his plane, because that blip is made brighter than all others by the addition of an extra spurt of voltage when the GAR pulses received represent the same spot on the scope as that at which the Self-Distance and Self-Azimuth meters indicate the plane to be.

In order that the blips on the scope do not indicate the location of the planes flying at all altitudes, the pulses representing planes are modulated slightly according to their altitudes. This operation is the same as that discussed under Navaspector. With such an arrangement the plane's receiver can be adjusted so that only planes flying within five hundred feet of its altitude are shown on its scope.

The plane's direction of flight relative to its scope is given by a transparent disk with parallel arrows on it which is set over the scope and is controlled by a gyro heading mechanism.

When all the various Navar functions are combined into one system, they provide for a wealth of information to both the pilot and the ground personnel. Both pilot and ground watchers have a view of the general situation. The pilot knows what planes are at approximately his height and he also has a means other than his scope of determining his exact location. The ground station can learn the exact altitude of any plane, and it can communicate with the planes tuned to it easily and accurately. Both plane and pilot receive double sets of certain information from independent sources. This is important as a safety aid, for thus apparatus cannot get out of adjustment and yield incorrect results without being noticed.

Another major feature to Navar is the way parts of it can be adopted piecemeal and then welded into a single unit which makes combined use of its equipment. A receiver used in the Self-Azimuth operation can be used at the same time for the Navamandar function. The result is that, while any one operation can require as many as two receivers and one transmitter in the plane and two receivers and two transmitters on the ground, the whole Navar unit requires only two receivers and one transmitter on the plane and four receivers and three transmitters on the ground.

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HEATING A PIECE OF METAL BY OPEN FLAME, BLOW-TORCH OR FURNACE IS RELATIVELY SLOW— APT TO LEAVE SCALE... IT'S HARD TO HEAT ONE SPECIFIC AREA WITHOUT HEATING THE WHOLE PIECE.

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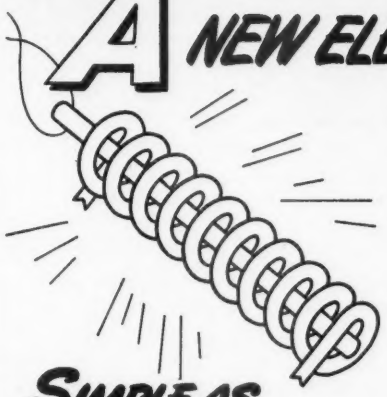

AMAZING PRODUCTION TOOL RECTIFIES ORDINARY 60-CYCLE CURRENT THEN STEPS IT UP TO 450,000 CYCLES. A MAGNETIC FIELD OF HIGH DENSITY IS SET UP IN WORK COIL AND WHEN METAL IS INTRODUCED INTO THIS FIELD, PASSAGE OF CURRENT CAUSES POWER LOSSES WHICH PRODUCE HEAT WITHIN THE METAL WITH INCREDIBLE SWIFTNESS.

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BIGGEST OF ALL IN RANGE OF INDUSTRIAL PRODUCTS

COSMIC RAY PHENOMENA

(*Continued from page 150*)

from a westerly direction, and therefore whether most of the cosmic rays are negative or positive. Professor Rossi of M. I. T., who was the first to propose the above scheme, has shown by experiment that most of the rays come from a westerly direction, hence positively charged cosmic rays seem to be more numerous than negative ones. We must note that there is no upper limit to the energies which the cosmic rays which reach the earth may have. Furthermore, we should note that rays with energies in excess of 6×10^{10} ev. are not appreciably deflected by the magnetic field of the earth. Before we go on to the study of more cosmic ray phenomena, let us summarize the information we have gained thus far as follows: the cosmic rays which reach the earth are, at least in part, charged particles, mostly positive, with energies in excess of 6×10^{9} ev. and therefore possessing great penetrating power; they arrive from outer space, where their distribution is isotropic; and at sea level they have at least two components of different penetrating power.

In 1928, P. Shobelzyn, who was the first to use cloud chambers in photographing the path of cosmic rays, noticed that the tracks of the cosmic rays tended to come in groups. He discovered that the particles making the tracks must have originated in the walls of the chamber and consequently must have been secondary particles produced by the primary cosmic rays. Shortly afterward, Professor Rossi of M. I. T. showed how important these secondary effects were by the use of coincidence counters. The most convincing method of showing that cosmic radiations do produce secondaries consists of plotting the change of ionization produced by shielding the counters against the thickness of the shield used. The ionization produced by the cosmic rays is actually increased when thin shields of lead are placed above the counter! This occurrence can be explained only if we assume that the cosmic rays produce showers of secondary particles in the lead. Since ionization depends more on the number of ionizing particles than on their energy, the secondary particles will produce more ionization than the energetic primary ray. Of course, if the thickness of material is increased even further, the ionization begins decreasing, since a great many of the secondaries are being absorbed. The curve for this reaction is given in Figure 2. This curve is often called the Rossi curve, in honor of Professor Rossi, who was the first to perform the above experiments.

After they had established the existence of these showers of secondary particles, the physicists investigated the properties of the individual particles. The apparatus they used consisted of a Wilson cloud chamber placed between the poles of an extremely strong magnet of about 1000 gauss, which produces an effect similar to that of the earth's magnetic field. A charged cosmic ray passing through the cloud chamber is deflected by the powerful magnet; hence the track of water droplets which the cosmic ray leaves will be curved. By measuring the direction and the amount of curvature, it is possible to accurately estimate the sign and kinetic energy of the cosmic ray. By this scheme of analysis, the secondary cosmic rays present in the showers were found to have the mass of electrons. However, a large number of the tracks were curved in the opposite direction to that in which negative particles would go. Either these tracks were made by positive electrons coming downward or by electrons traveling away from the earth. Anderson proved that the former case is the true one in the following manner: by dint of great patience he obtained a cloud chamber photograph of the path the disputed particle followed in crossing a cloud chamber which contained a plate of lead placed horizontally across the center of the chamber. The path was curved more below the plate than above. A particle crossing the plate from above should lose energy, and hence have a more curved path below; a particle crossing the plate from below should have its path more curved above the plate. Since the former case was shown to be true in Anderson's photograph, the secondary particle was obviously a positron. Anderson received a Nobel prize for his work.

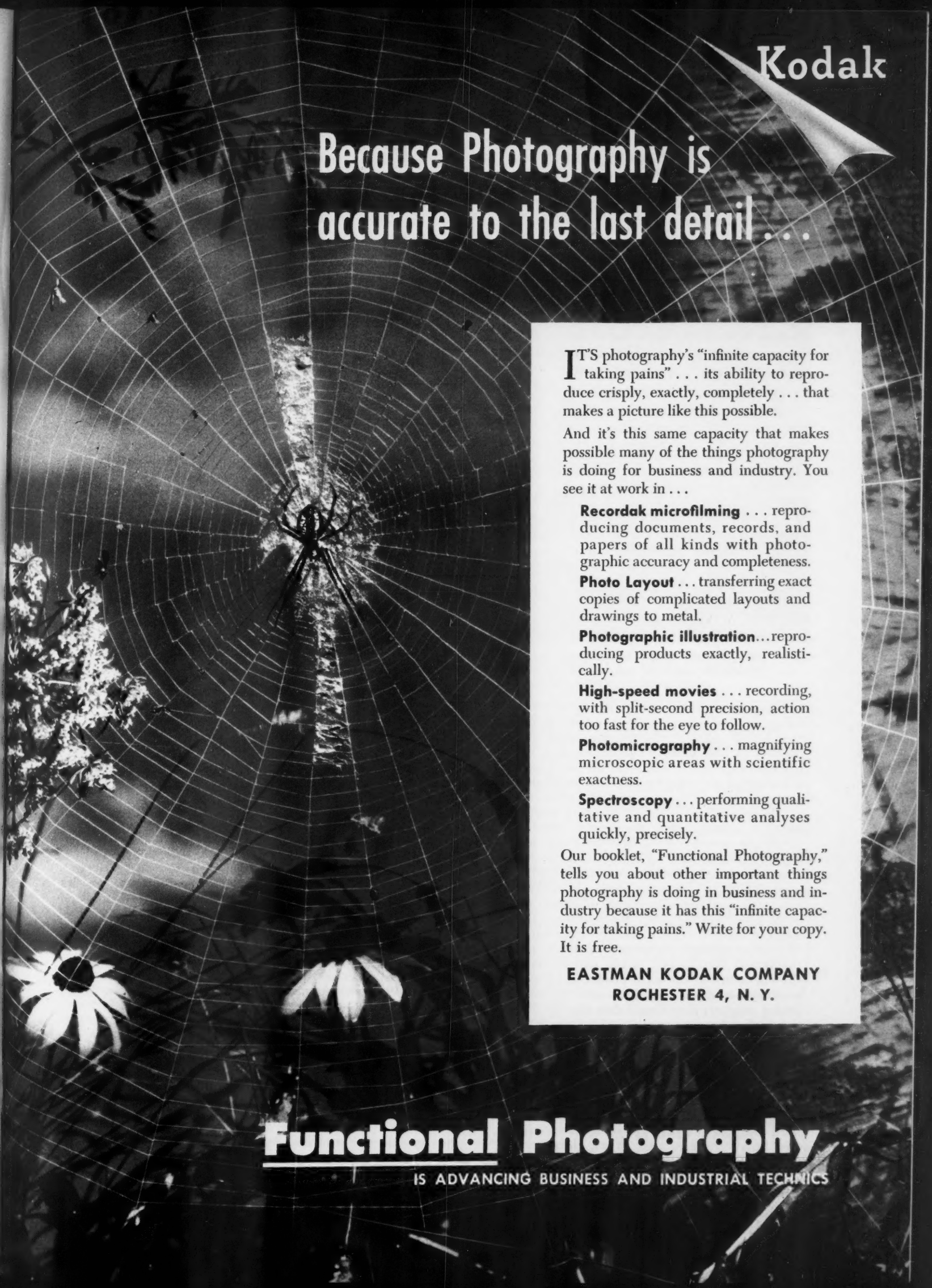
Soon after Anderson's success, the process of pair formation was discovered and investigated. Pair formation is the process by which an energetic photon materializes into a positron and an electron. Since the photon has no charge, the net charge of the particles it produces must be zero — as is the case with an electron — positron combination; since energy must be conserved, the energy of the photon must be the equivalent of at least twice the mass of an electron, according to the well-known relation:

$$E = mc^2$$

Since the mass of an electron is equivalent to 5×10^{5} ev., the photon must have a minimum energy of 10^{6} ev. Any excess energy possessed by the photon is converted into the kinetic energy of the product electron and positron. There is still one more law that must hold in this process; namely, the conservation of momentum. It is possible to show that momentum cannot be conserved in the process of pair-formation unless a third particle is involved; hence this process cannot take place in a vacuum. Not long after the discovery of pair formation, the existence of its inverse phenomenon was demonstrated. In other words, it was shown that when a slow electron and a slow proton meet, they fuse and disappear as two quanta of light, traveling in opposite directions so that the law of conservation of momentum is not violated. Later on, still another similar phenomenon was observed; an electron or positron may be greatly retarded in passing by a nucleus, the kinetic energy liberated by this retardation being emitted in the form of a photon. This process is known as Bremsstrahlung. In the light of these phenomena, the physicists were soon able to interpret the process of shower formation in the following way: a fast electron passing through matter produces photons by retardation (Bremsstrahlung); these photons produce pairs; each electron of these pairs produces more photons, etc. Soon a shower is formed which continues until the photons no longer have the requisite 10^{6} ev. energy. Since electrons are retarded very effectively by only the heavier elements, showers are formed much more often in the presence of heavy elements. Consequently, the Rossi curve shows a large initial increase of cosmic ray ionization only when elements like lead are used as a shield. By placing coincidence counters farther and farther apart horizontally, several physicists discovered that showers of over a million particles frequently occur over an area of about an acre. These showers must have been produced in the middle atmosphere since local showers could not possibly spread out so far. Therefore, great numbers of secondary electrons must exist in the middle altitudes.

In many cloud chamber pictures of cosmic ray particles, there can be seen the tracks of heavy particles such as the proton. In addition, photographic plates often contain the path of such particles. Niehls Bohr

(*Continued on page 170*)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Answers to last month's

Can You Do It?

Problem 1: Our poor hunter should simply pack his gun in a cubic crate one yard on a side. It will be found that the gun will just fit if it is placed as the diagonal of the cube. The length of the diagonal is just a little more than the required five feet two inches.

Problem 2: In the long run, B is safe in betting any amount of money he feels like wagering! This problem is the old St. Petersburg paradox and can best be explained on the basis of expectation. B's probability of winning on the first throw is ½, and he wins $1. At the same time, his probability of winning on the second throw is ¼, at which time he wins $2. Thus his probability of winning on any one throw of the coin is $\frac{1}{2^n}$ at which time he will win 2^{n-1} dollars. B's expectation on every throw of the coin is the product of the probability and the yield, and inspection will show that B's expectation on every throw of the coin is 50 cents. His expectation on the overall game is thus simply an infinite series, all of whose terms are 50 cents, or infinity! Anyone want to play?

J. W. W.

COSMIC RAY PHENOMENA

(*Continued from page 168*)

has explained this cosmic ray phenomenon in the following way: when cosmic rays pass through a nucleus, the nucleus partially disintegrates, with the emission of protons and neutrons. This phenomenon is often called nuclear evaporation. Many of the more powerful bursts of ionization recorded by counters are produced by such protons rather than by electron showers.

In measuring the depth to which the hard component of cosmic rays penetrated, the experimental physicists wanted to know how much energy an electron had to have in order to reach a given depth. The theoretical physicists, upon solving the problem, were able to say that no electron — with the possible exception of those with energy in excess of 10^{15} ev. — could penetrate the given depth of material because an electron loses so much energy in producing photons. The experimental physicists, in order to check the theoretical conclusions, made careful calculations of the curvature in the path produced by the hard component in a cloud chamber under the influence of a strong magnet; they found that the theoreticians were right; the observed particle had a much greater mass than that of the electron. Shortly before, the Japanese mathematician Yukawa had postulated the existence of an unusual particle, which he called a heavy quantum, while developing a new theory of nuclear structure. This particle, which was soon renamed the mesotron, had just the properties which the cosmic ray hard component was supposed to have; namely, a mass two hundred times that of an electron, and a unit charge, either positive or negative. Further experimentation soon established the existence of the mesotron. Yukawa had predicted that the mesotron would have a very unusual property; namely, it would decay after a half life of a few microseconds. Yukawa's prediction was soon verified experimentally by comparing the absorbing power of the atmosphere with that of an equivalent thickness of lead. Recently Rossi, among others, has developed a new way to measure the mean life of a mesotron: the passing of a mesotron through a counter is recorded. Below the counter is a thick block of lead which slows the mesotron down so much that its decay electron is produced close enough to the first counter so that it can be detected by a second counter. The difference in time between the recordings gives the mean life of the mesotron. Although the mean life of the mesotron in its own system of reference is about two microseconds, the Lorentz-Fitzgerald contraction of time, which takes effect in the case of particles moving as fast as mesotrons, makes its lifetime appear longer to us. Several physicists have taken cloud chamber pictures of mesotron decay which show that an electron is produced upon the decay of a mesotron. However, an electron could not be the only particle produced by the halted mesotron, or the law of conservation of momentum would be violated. Consequently, the physicists had to invent a new particle, which they named the neutrino, or little neutron. As the name implies, the neutrino has no charge and very little mass (its rest mass is zero). We can now see that the hard portion of the cosmic rays consists of a particle with mass 200 times that of an electron, a unit charge of either sign, and the property of decaying within a few microseconds with the emission of an electron and a neutrino.

Now is the time to summarize all the information we have gained about the cosmic rays, so that we may grasp the underlying pattern. The best way to do this is to follow the course and the effects of the cosmic rays from the time they first approach our solar system. We shall put off until later any discussion of the origin of cosmic rays. According to present hypotheses primary cosmic rays consist of some combination of electrons, protons and photons, the latter being present in small numbers at best. As the electrons and/or protons approach the earth, they are first brought under the influence of the magnetic field of the sun and then under that of the earth. The deviating effect of these two fields is strong enough so that any particles with energies below 6×10^9 ev. are deflected away from the earth. Those particles with energies between 6×10^9 and 6×10^{10} ev. reach the earth following a curved path, while particles with energies greater than 10^{11} ev. are not noticeably affected by the geomagnetic fields. We can see, therefore, that the cosmic rays, which were isotropic out in space, have assumed a definite structure by the time they reach the earth's atmosphere. From this point, either or both of two hypotheses may be followed. We will assume first that the cosmic rays are streams of energetic electrons and second that they are streams of protons. A stream of primary electrons would, upon striking the atmosphere, produce photons by the process of sudden retardation. These photons would give rise to a positron and an electron, which would in turn produce more photons. Thus, increasingly large numbers of secondary particles would be produced until a depth of atmosphere corresponding to three feet of water had been reached, after which absorption would decrease the number of secondary rays. We will have to assume that the mesotrons would be produced by very energetic photons in a

(*Continued on page 172*)

Du Pont *Digest*

Items of Interest to Students of Chemistry, Engineering, Physics, and Biology

High-Pressure Synthesis Opens New Chemical Fields

A Challenge to Research Men and Engineers

The use of techniques involving pressures up to and above 1,000 atmospheres (15,000 lbs. per sq. in.) has had a tremendous influence on chemical manufacture in the past twenty-five years.

The availability of unlimited quantities of nitrates via ammonia from nitrogen of the air by high pressure synthesis has greatly affected chemical economics as well as agriculture.

The plastics industry, too, has benefited greatly by the reduction in price of urea from about 80¢ lb. to less than 4¢, and methanol (to give formaldehyde) from $1.25 gal. to less than 25¢.

High pressure syntheses have also participated in a major way in the development of entirely new products such as nylon and polythene. In fact, starting from coal, air and water, Du Pont now makes over 120 widely used products.

In addition to improving the existing processes of manufacturing ammonia, methanol, higher alcohols, urea and other important chemicals, Du Pont organic and physical chemists, chemical, mechanical and metallurgical engineers have discovered and developed high pressure syntheses for the following: ethylene glycol; hexamethylene diamine; acetic, propionic and hydroxyacetic acids; methyl formate; C_8-, C_{10}- and C_{12}- alcohols; and numerous others.

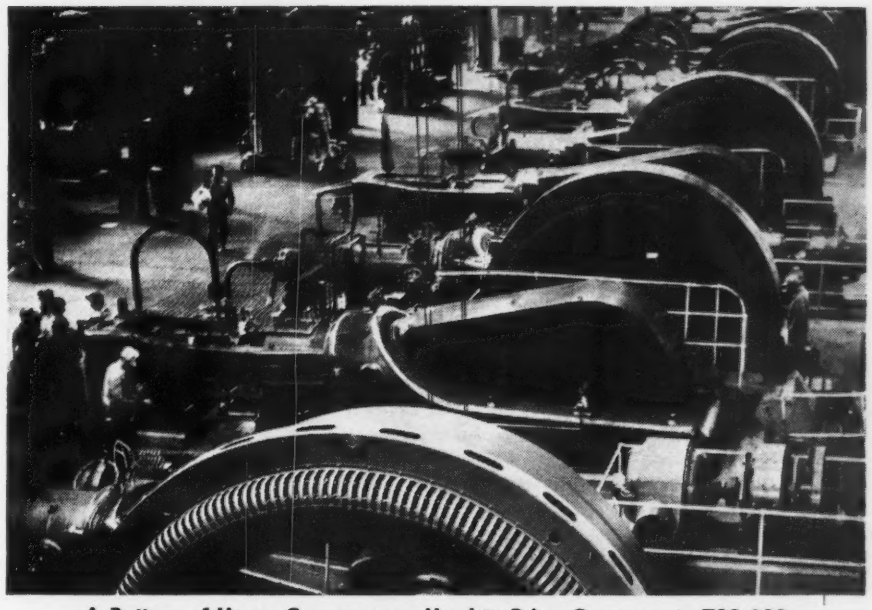
Advantages and Problems

The use of high pressures offers numerous advantages familiar to technical students, such as: (1) forcing an equilibrium in the direction of a volume decrease, (2) overcoming the reversing effect of high temperatures in exothermic reactions, (3) increasing reaction and through-put rates and (4) providing, in some cases, a liquid phase which might not otherwise be present.

The synthesis of urea from carbon dioxide and ammonia is a good illustration of some of these principles:

$$CO_2 + 2NH_3 \rightleftharpoons CO(NH_2)_2 + H_2O$$

With three moles of reactants and only two of resultants, increase of pressure gives an expected increase in conversion.



A Battery of Hyper Compressors Used to Bring Gases up to 700-900 Atmospheres Pressure in the Ammonia and Methanol Syntheses.

At the same time, the gaseous reactants are forced into the liquid phase to give higher concentrations and again better conversion. The reaction rate and therefore the rate of passage through the reaction chamber are both increased by increasing the temperature under high pressure conditions. There are other equilibrium considerations that affect the industrial production of urea, but they are too lengthy to discuss here.

Along with its advantages, the use of high pressure gives rise to problems that often severely tax the abilities of engineers and chemists. For example, (1) difficulties of design of packing glands, valves, connecting rods, closures, etc., increase rapidly with increased pressure, (2) extraordinary corrosion problems arise in which even stainless steels are attacked and cannot be used, (3) ordinary steels are permeable to hydrogen at higher pressures and temperatures. These are but a few illustrations of the challenge that high pressure studies present to the technical man and particularly to the metallurgical and mechanical engineer.

High pressure synthesis has now become a separate field of industrial chemistry with an apparently limitless future.

Questions College Men ask about working with Du Pont

What kind of a technical organization does Du Pont have?

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COSMIC RAY PHENOMENA

(Continued from page 170)

process analogous to that of pair formation. The primary electrons with energies below 10^{13} ev. would poduce rather weak showers which would die out in the middle atmosphere. The mesotrons produced by these electrons would also decay at that height, giving rise to the small showers which constitute most of the soft component at sea level. On the other hand, showers produced by primary electrons with energies in excess of 10^{13} ev. would still be strong at sea level, these showers producing the rather infrequent large bursts of activity which we notice. The mesotrons produced by the energetic electrons would be able to penetrate considerable distances into the earth, after which they would decay with the emission of small showers. The energy received from the cosmic rays, which is equivalent to that received as light from all stars other than the sun, would ultimately be converted into heat. If we assume that protons are the primary cosmic rays, we would arrive at similar conclusions, except that the production of mesotrons would be accounted for by the splitting up of protons under the influence of nuclei, into positive and negative mesotrons, with the positive charge predominating. The latter theory seems to be in better accord with the observed fact that most cosmic rays are positive, although the former theory accounts more satisfactorily for the large number of secondary electrons produced at high altitudes. Neither theory provides a wholly adequate explanation of the phenomenon of nuclear evaporation. In any event, we should realize that there might well be other forms of primary radiation with which we are not familiar.

Now we can take up the fascinating problem of the origin of cosmic rays. There are three recognized theories of the origin of cosmic rays. Millikan has suggested that if an atom of atomic number about twenty were to be completely destroyed, one electron pair of the requisite 10^{10} ev. energy would be formed. However, there are two main objections to this theory: an electron stream flowing from an area of concentrated matter should have a large number of photons accompanying it; this is not the case with cosmic rays. Furthermore, it would seem that any electrons produced in such a way would be reabsorbed by the surrounding matter. In view of the above objections it was suggested that high energy electrons could be produced in the empty space within our galaxy if the center of our galaxy were positively charged and the perimeter negatively charged. However, if this were the case, we should be able to note marked anisotropy in the high energy cosmic rays reaching the earth; this is not the case. Furthermore, there would have to be some mechanism within our galaxy which would continually replenish the charge difference between the inner and outer portions of the galaxy, since the continual flow of electrons would tend to remove this charge difference. H. Alfvén has proposed that the observed accelerations could be given electrons in the very powerful magnetic fields which exist between double stars. However, it is not likely that such a rare mechanism could produce the very abundant cosmic rays.

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SODIUM BICARBONATE
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SILENE EF *(hydrated calcium silicate)*
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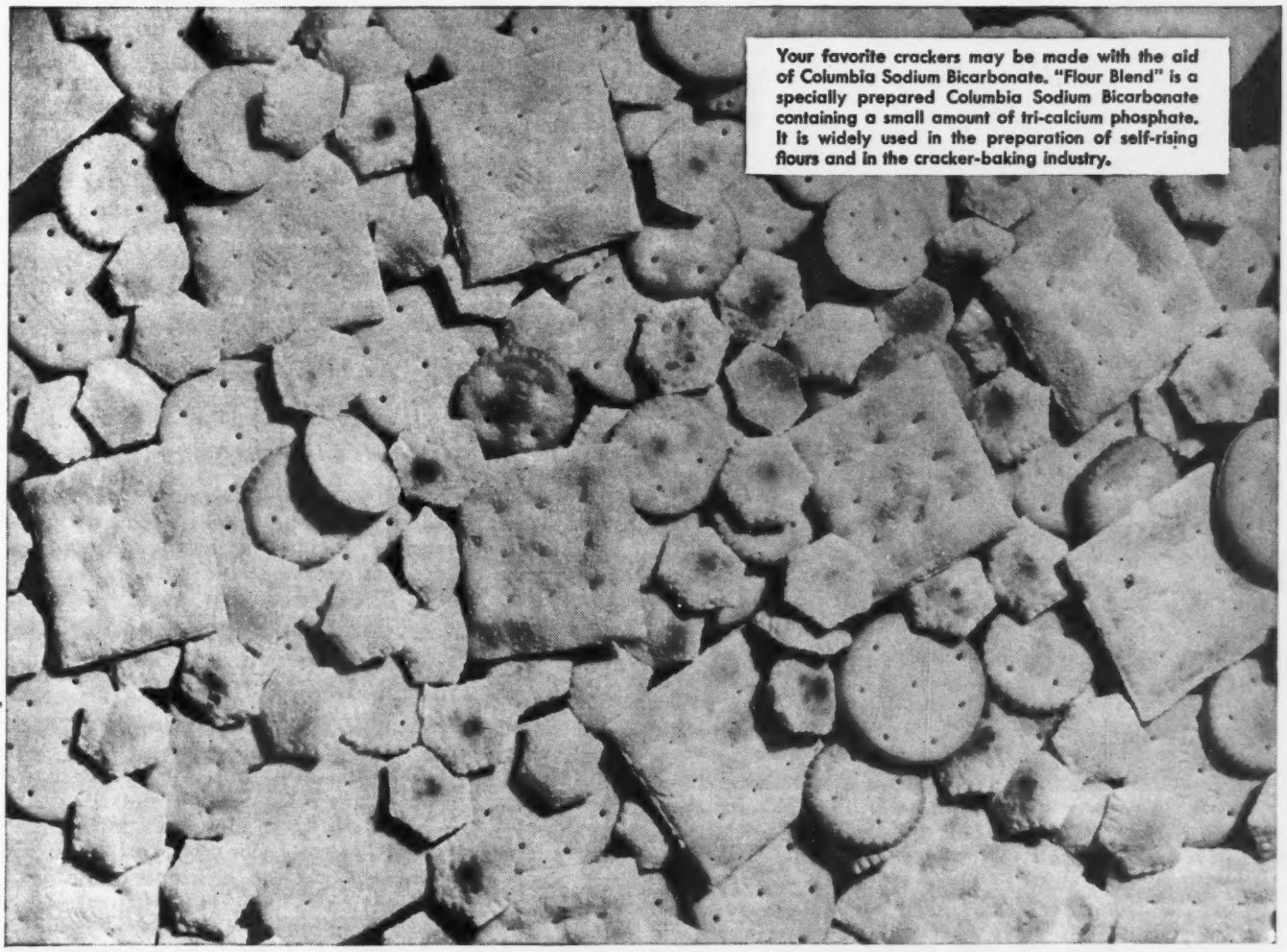

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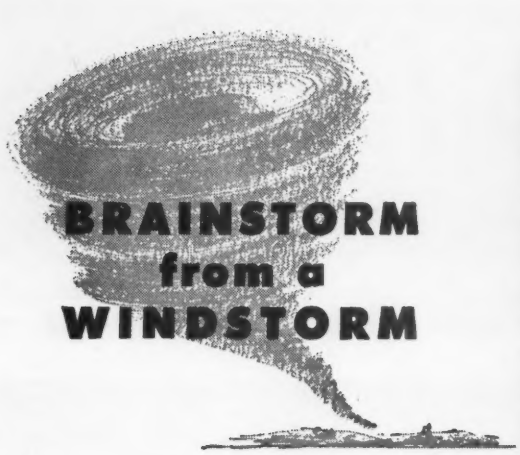

NATURE held the original patent on the whirling force of the cyclone. But it was B&W who first put the idea to work separating water and solids from steam to improve the performance of boilers.

B&W calls its adaptation of nature's destructive force to useful work, the *Cyclone Steam Separator*. Its use in power boilers makes larger, more rapid swings in power loads possible, raises boiler and turbine efficiency and cuts maintenance costs.

Development of the Cyclone Steam Separator is but one of many examples of imaginative engineering at B&W. Testimony that, while old enough to have pioneered important advances in many divergent fields, B&W is young enough to have new ideas—ideas for all industries, in connection with present problems or future plans.

Through this progressive policy of continuous research and development, B&W offers technical graduates excellent career opportunities in diversified fields of manufacturing, sales, engineering, research and in many other vocations. Send for the booklet "Your Career." It tells the story of the Babcock and Wilcox Company in terms of your future.

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COSMIC RAY PHENOMENA

(*Continued from page 170*)

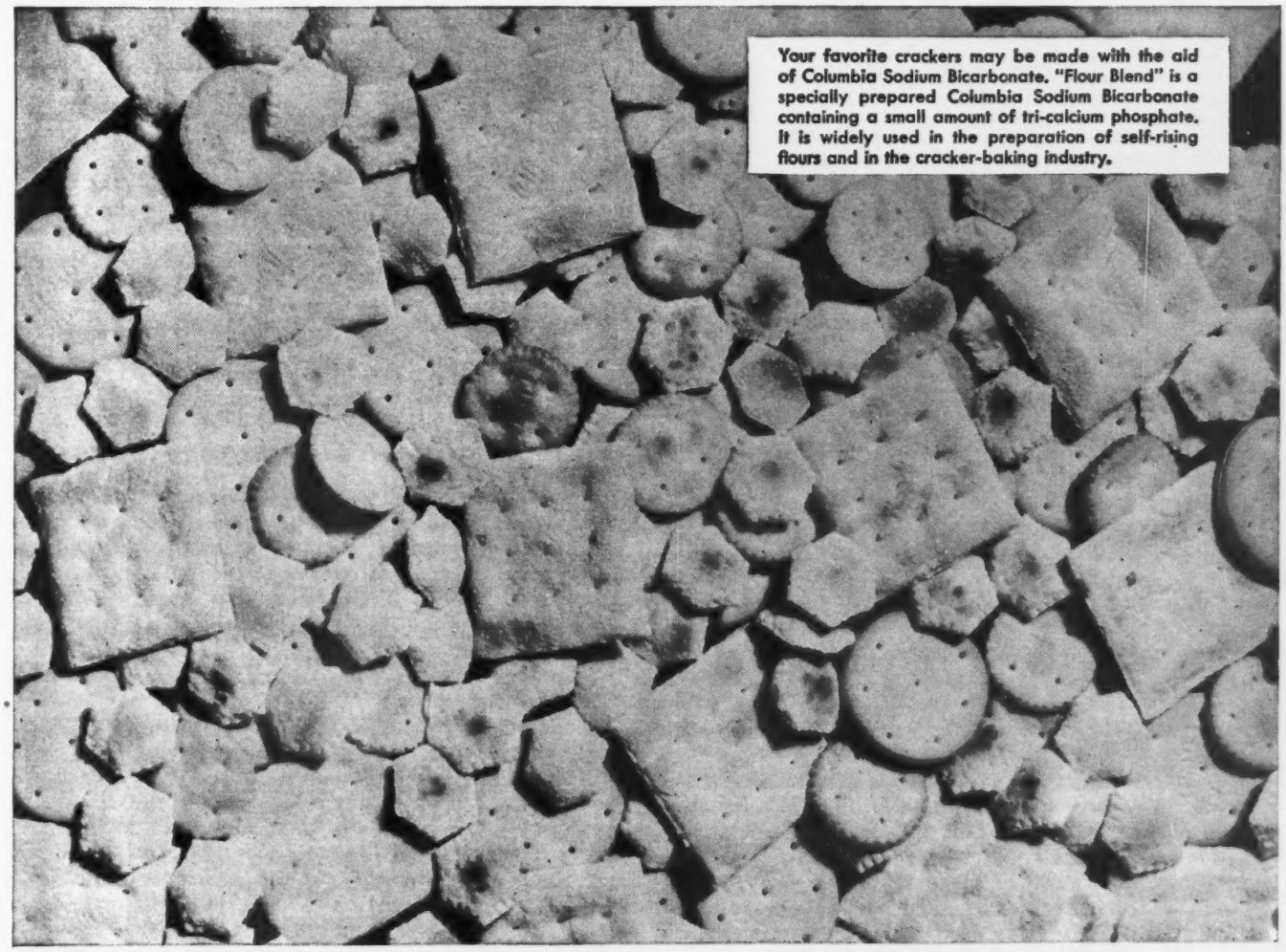
process analogous to that of pair formation. The primary electrons with energies below 10^{13} ev. would poduce rather weak showers which would die out in the middle atmosphere. The mesotrons produced by these electrons would also decay at that height, giving rise to the small showers which constitute most of the soft component at sea level. On the other hand, showers produced by primary electrons with energies in excess of 10^{13} ev. would still be strong at sea level, these showers producing the rather infrequent large bursts of activity which we notice. The mesotrons produced by the energetic electrons would be able to penetrate considerable distances into the earth, after which they would decay with the emission of small showers. The energy received from the cosmic rays, which is equivalent to that received as light from all stars other than the sun, would ultimately be converted into heat. If we assume that protons are the primary cosmic rays, we would arrive at similar conclusions, except that the production of mesotrons would be accounted for by the splitting up of protons under the influence of nuclei, into positive and negative mesotrons, with the positive charge predominating. The latter theory seems to be in better accord with the observed fact that most cosmic rays are positive, although the former theory accounts more satisfactorily for the large number of secondary electrons produced at high altitudes. Neither theory provides a wholly adequate explanation of the phenomenon of nuclear evaporation. In any event, we should realize that there might well be other forms of primary radiation with which we are not familiar.

Now we can take up the fascinating problem of the origin of cosmic rays. There are three recognized theories of the origin of cosmic rays. Millikan has suggested that if an atom of atomic number about twenty were to be completely destroyed, one electron pair of the requisite 10^{10} ev. energy would be formed. However, there are two main objections to this theory: an electron stream flowing from an area of concentrated matter should have a large number of photons accompanying it; this is not the case with cosmic rays. Furthermore, it would seem that any electrons produced in such a way would be reabsorbed by the surrounding matter. In view of the above objections it was suggested that high energy electrons could be produced in the empty space within our galaxy if the center of our galaxy were positively charged and the perimeter negatively charged. However, if this were the case, we should be able to note marked anisotropy in the high energy cosmic rays reaching the earth; this is not the case. Furthermore, there would have to be some mechanism within our galaxy which would continually replenish the charge difference between the inner and outer portions of the galaxy, since the continual flow of electrons would tend to remove this charge difference. H. Alfvén has proposed that the observed accelerations could be given electrons in the very powerful magnetic fields which exist between double stars. However, it is not likely that such a rare mechanism could produce the very abundant cosmic rays.

Industry Relies on COLUMBIA for Essential Chemicals

SODA ASH	CAUSTIC ASH
CAUSTIC SODA	PHOSFLAKE *(bottle washer)*
LIQUID CHLORINE	SODA BRIQUETTES *(iron desulphurizer)*
CALCIUM CHLORIDE	CALCENE T *(precipitated calcium carbonate)*
SODIUM BICARBONATE	SILENE EF *(hydrated calcium silicate)*
MODIFIED SODAS	PITTCHLOR *(calcium hypochlorite)*

$NaHCO_3$—A white, crystalline salt found in mineral springs and in huge alkali deposits in California, Wyoming, and Nevada. Sometimes known as "baking soda," "cooking soda," and "saleratus" this sodium hydrogen carbonate is produced commercially by the ammonia-soda process, then refined and purified for a variety of uses in the preparation of foods and medicines. Sodium Bicarbonate is also used in leather and textile manufacturing, gold and platinum plating, fire extinguishers, wool and silk treating, and ceramic manufacturing.



Your favorite crackers may be made with the aid of Columbia Sodium Bicarbonate. "Flour Blend" is a specially prepared Columbia Sodium Bicarbonate containing a small amount of tri-calcium phosphate. It is widely used in the preparation of self-rising flours and in the cracker-baking industry.

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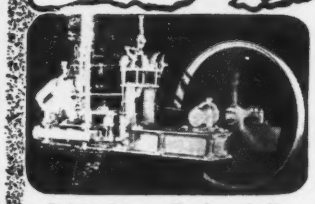
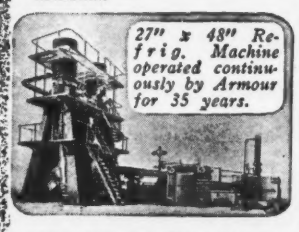
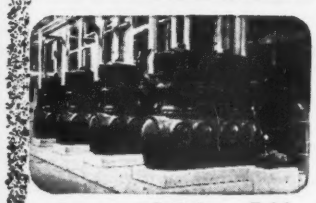


Frick Steam Engine, built in 1856, now in the Ford Museum.



27" x 48" Refrig. Machine operated continuously by Armour for 35 years.



Large 4-Cylinder Frick Compressors of today with 300-h.p. Motors.

So writes one of our customers in December, 1860. Living south of the Mason-Dixon Line, he complained of "Harrisburg bills" that "We cannot do anything with that money here."

This was seven years after George Frick had established his steam engine business (1853). The Company which still bears his name has since lived through four wars and many nationwide financial crises.

In 1882 Frick Company began making the refrigerating machinery which is now the standard of excellence throughout the world. Many of the Frick compressors built forty or fifty years ago are still in daily operation. One of them has been on the job nearly 60 years.

That's the kind of reliability only FRICK equipment gives. Write for literature.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, now in its 30th year, is approved under the G.I. Bill of Rights.

Frick Co., Waynesboro, Pa.

THE SUN'S SONS

(*Continued from page 155*)

Saturn weighs 95 times as much as the Earth, travels at 6 m.p.s. and takes 29.5 years to revolve. It is a fairly bright object, rising at sunset, and keeping an all-night vigil near the constellation Leo the Lion, in the northwest sky.

Saturn has always been known for its three rings, which are made up of countless rock fragments, probably the remains of a tenth moon, which came within the gravitational danger zone of the planet, and was annihilated.

Uranus, with its four moons, is next. It is 1.77×10^9 miles out, has a diameter of 32,000 miles, travels at 4.2 m.p.s. and takes 84 years to revolve. It is the constellation Taurus, the Bull, where it is barely visible to the naked eye.

Neptune has one moon, takes 164.8 years at 3.4 m.p.s. to revolve in an elliptical orbit 2.76×10^9 miles from its parent. It can only be seen with a telescope, and is not particularly exciting to look at.

Pluto, the last of the planets, and the most recently discovered, has not been known long enough to reveal accurate knowledge. It is somewhat smaller in size and mass than the Earth, travels at 2.9 m.p.s. and takes 248 years to complete its lonely orbit 366 million miles out in nowhere.

These then are the main members of the Sun's family. The lesser bodies, comets, asteroids and so forth will be taken up in a later issue. They are equally as important as the planets, for they are visitors from other worlds and other stars, bringing with them vital knowledge of our own Solar System, and of worlds beyond.

COLOR PHOTOGRAPHY

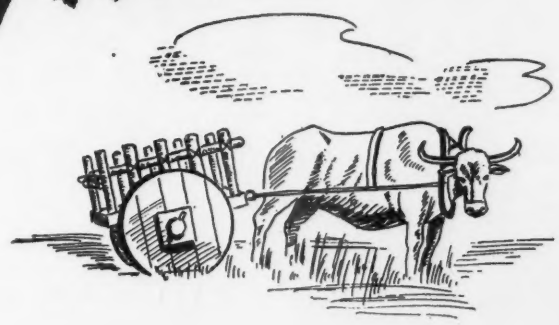
(*Continued from page 154*)

capable of giving as good results as any other process, and has the added advantage that successive color prints can be made very cheaply, as the matrixes can simply be redyed and retransferred on another piece of paper. At least ten prints can usually be made from one set of matrixes, if reasonable care is taken in handling them.

A few processes, not on the market, are capable of making prints directly from the transparency without the use of separation negatives. However, these methods are extremely variable, slow, and usually tedious, and therefore cannot be seriously considered as a method of producing color prints in the case of the amateur. A discussion of these methods can be found by referring to "History of Color Photography."

Many new processes and modifications of old processes can be expected on the market in the reasonably near future. However, only two processes are available for use at the present time. One must remember that a new surge in the demand for color film has occurred recently, due to the introduction of Ektachrome, Ansco Color, etc., and the demand for good methods of producing color prints will increase with this increase in demand for film. Therefore it is not unreasonable to expect that new processes will be introduced as soon as possible.

Be a better engineer- know TIMKEN BEARINGS



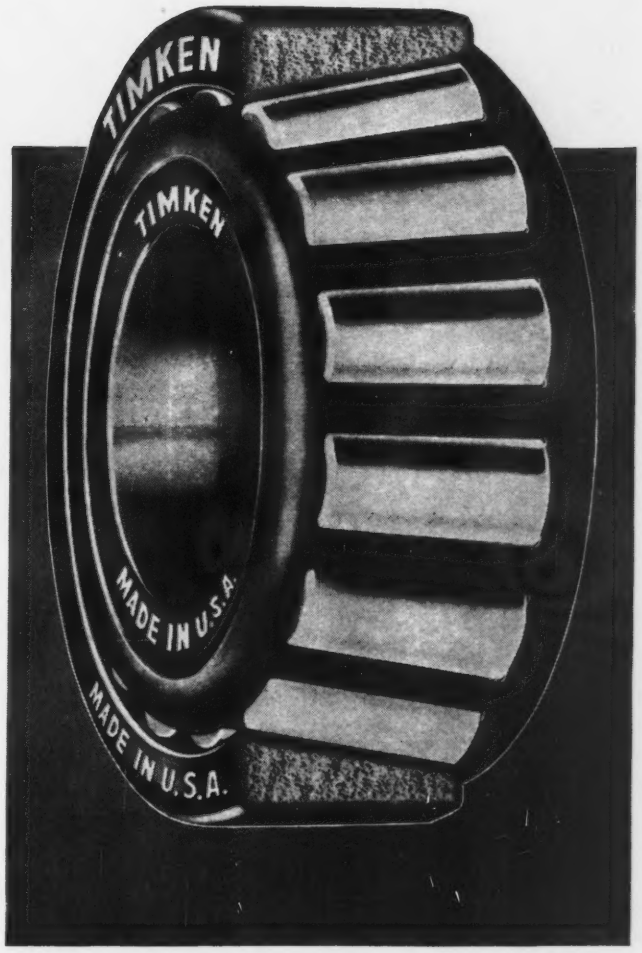
A thorough understanding of the design and application of Timken Tapered Roller Bearings will enable you to solve at least 90% of the bearing problems you are ever likely to encounter when you begin your engineering career after graduation.

When primitive man first made a hole in a crude wooden wheel and slipped it over a wooden axle he achieved the first function of a bearing — support.

Support for wheels, shafts, gears and other rotating parts still is the primary purpose of bearings, but several other vital bearing requirements are needed in modern equipment.

Ability to carry radial loads, thrust loads or both together in any combination is one of the most important of these. Ability to hold moving parts permanently in alignment is another. Then of course there is the reduction of friction, although this quality is common, in varying degrees, to all anti-friction bearings.

The tapered roller bearing was introduced by The Timken Roller Bearing Company nearly 50 years ago and today is universally used throughout industry and transportation. Every genuine Timken Bearing is unmistakably identified by the trade-mark "TIMKEN" stamped on cup and cone.



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TAPERED ROLLER BEARINGS

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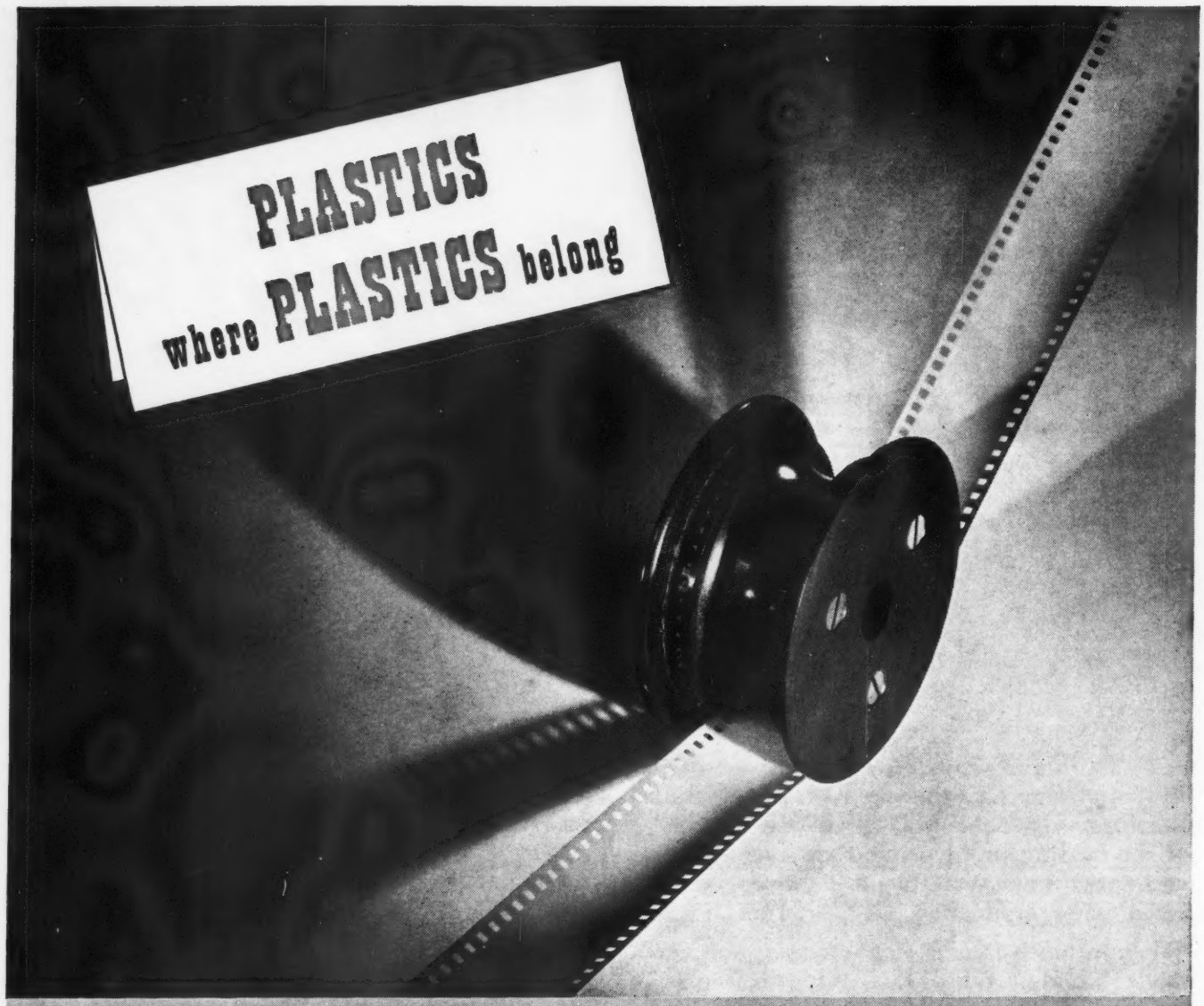

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The film carrier illustrated is only one of many types made from Synthane laminated plastics. Synthane is well-suited for the job because it stoutly resists the corrosive action of developing solutions.

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Whenever in your future work you have an application for laminated plastics, let us know about it—*before* you design, if possible.

Synthane's help includes design, selection of the right material, and fabrication by men who know plastics. Synthane Corporation, Oaks, Penna.

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Thus far, such problems have been solved by our "Mass Precision" method — a method perfected by Nichols for mass producing parts and assemblies to the most precise dimensions, on a strictly interchangeable basis. Such parts are *low in cost* — so low, in fact, that you will doubtless find "Mass Precision" cheaper than less accurate means.

Someday Nichols may be able to fill an order to slice off a layer of atoms — in the meantime you should investigate the present quality of Nichols' parts and assemblies. Write for the new booklet "Mass Precision". It shows what Nichols has done for others — suggests what can be done for you.

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FLIGHT TEST ENGINEER

The Story of

CURT TALBOT

AFTER he came on "Test" with General Electric in 1936, Curt Talbot kept right on studying electrical engineering, this time in the company's general and commercial courses.

Between hours of work and study he went out to the Schenectady airport to practice flying, piling up 500 flying hours and obtaining his commercial rating.

By taking lessons in both these fields—and taking them seriously, Curt was, unknowingly, giving himself the best possible preparation for his present job—that of Manager of the new General Electric Flight Test Laboratory.

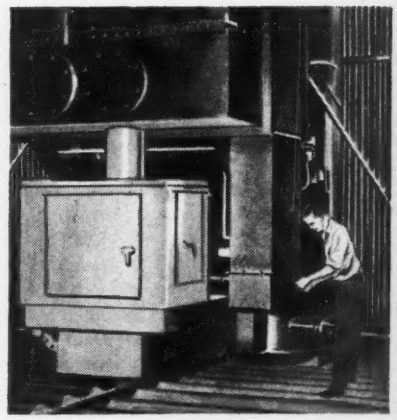
During his first years with the company, Curt tested transformers, motors, industrial control apparatus. He did application engineering on paper-mill and printing-press equipment. He worked as a sales assistant.

But when the war placed a heavy demand on G. E. both for aircraft equipment and for men who understood it, Curt's interest in flying was remembered. He was assigned to work on turbosuperchargers.

Today, ten years out of Illinois, Curt Talbot manages a laboratory large enough to house its own fleet of test planes. He supervises the testing of jet-propulsion and gas-turbine engines, radar applications, turbosuperchargers, aircraft instruments, automatic pilots and control systems. And he directs the use of the "flying laboratory"—a B-29 especially equipped for test flights.

Next to schools and the U.S. Government, General Electric employs more college engineering graduates than any other organization.

Curt helped pay his way through the U. of Illinois by repairing radios in his spare time. He majored in electrical engineering.



On Test with G.E., he was assigned to high-voltage transformers. He continued his engineering studies by taking G-E courses.

In his spare time Curt learned to fly. His knowledge of engineering plus flying gave him the opportunity, in 1940, of joining the Company's turbosupercharger program.

Today Curt is Manager of the G-E Flight Test Division. He directs the big new G-E Flight Laboratory, center of tests on jet-propulsion engines, gas turbines, etc.

GENERAL ELECTRIC

The Murray Printing Company
Cambridge, Massachusetts